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## The Enforcement of Specifications.

The presidential address of Dr. Charles B. Dudley before the American Society for Testing Materials, published in The Engineering Record of June 29, is suggestive of many important questions which arise in the execution of engineering works of magnitude. Dr. Dudley's observations naturally bear chiefly upon the quality of materials to be delivered to the consumer. His life work, although thorough and most extended, has been devoted with highly excellent results largely to investigations regarding the quality of a great range of materials used by the Pennsylvania Railroad Co., and yet his treatment of the subject as a whole is applicable in essence to the broad field of engineering construction as well as to engineering materials, the former in general terms including the latter. As indicated by him the necessity of inspection in order to secure the enforcement of specifications does not in the slightest degree, as a matter of fact, reflect upon the integrity or the motives or the capacity of the producer of materials or of the contractor who undertakes to build great engineering works. The conditions under which materials are produced or work performed are of almost limitless variety, and it is to the real interest of the producer and the contractor as well as to the engineer and owner to secure in every part of it excellence of material as well as efficiency in structural procedures. Further than this, it is one of the duties of the engineer to supply to his client an authoritative certification that the latter has obtained precisely what he has contracted to receive. It is not an uncommon experience where there is a suitable and reasonable co-operation between engineer and contractor to attain enhanced economy for the contractor as well as improved quality of material and work for the owner. One of the most common instances of this kind, although many might be cited, was the result of the cement inspection in connection with the construction of the Rapid Transit Subway in New York City. The engineering inspection of the cement was carried on in connection with that of the manufacturers to the marked mutual advantage of both parties concerned, and what was accomplished there has many times been accomplished elsewhere and will be again.

Although it cannot be denied that the enforcement of specifications in many engineering works has led to sharp friction between engineers and contractors or producers, it can be said almost without exception that had there been a reasonable attitude of each party in interest to the other with even a moderate amount of tact on the part of the engineer, even such difficulties would largely, if not entirely, have disappeared. It is excessively difficult, in fact practically impossible, for any engineer, however experienced and highly qualified he may be to set forth correctly all the important conditions affecting both the quality of the materials and the character of procedures required in connection with the prosecution of an engineering work of unusual magnitude. The natural conditions affecting such work are never identical in any two cases and seldom nearly so. These differences of natural conditions which occur in the development of field and other structural procedures are so marked in passing from one work to another that, however scrupulously careful the fundamental features of construction are specified, it is simply impossible to anticipate all the exigencies that may arise and hence to formulate specifications which may not need modifications in the interests of both the client and contractor. Under such circumstances it is the part of the engineer to consider well to what extent he shall hold to the literal requirements of the specifications. It is his first duty to secure every excellence of material and structural procedure which the specifications call for; on these points there must be no concession and no reasonable contractor either desires or expects it. There may be, however, a wide legitimate range in opinion as to the ways and means of securing the essential ends set forth in the specifications and therein lies the necessity for the exercise of judicial functions by the engineer. It is precisely in this part of the work that unnecessary and even inexcusable friction so frequently arises between engineer and contractor. Even though specific procedures are prescribed for the accomplishment of certain portions of the work, if either the contractor or the engineer can independently or in co-operation devise more effective procedures for the attainment of the necessary ends, the mere letter of the specifications should not stand in the way of obtaining such an advantage. It matters little whether the contractor will save expense by such a procedure or not. It is his legitimate object to increase his profits if he can do so without prejudice to the quality of the work or materials. No engineer goes beyond a reasonable and proper concession in considering a proposition of this character from a contractor if he constantly keeps in mind the real purpose of his specifications and yields nothing which prejudices either the quality of material or efficiency of the work.

The specifications form a part of the contract which is essentially no less important than those parts which secure payment for the work done. In fact, it may be stated that the specifications form the real substance of the contract, the other portions being incidental although essential, and clearly the engineer cannot properly consent to any modification which militates against the real spirit of the agreement; nor should a contractor be permitted any modifications of procedures, or modifications in the supplying of the materials, which are not absolutely in harmony with the same spirit of the specifications. Neither of these observations, however, prevents to the slightest degree any reasonable modifications necessitated by conditions developed in the progress of the work and not originally anticipated. Such exigencies frequently cannot be met in a reasonable manner under a drastic, literal interpretation of contract conditions. It then becomes the duty of the engineer to exercise broadly his proper functions so as to relieve situations which might otherwise be unreasonable or even intolerable; and thus secure, in the completed work, precisely what was really contemplated by the specifications. It is only the part of wisdom to make specifications sufficiently elastic to permit such an enforcement which, while guarding the interests of the client, is also consistent with the highest efficiency in the contract operations and amenable to any exigencies of natural conditions that may arise.

## The Street Lighting Situation.

Indications are very plain that within a short time city engineers and electricians and others who represent the public interest will be hard up against some new and revolutionary propositions in street lighting. At its recent convention the National Electric Light Association adopted a series of specifications for street lighting which are of very grave import and of which the association itself has probably hardly grasped the full significance. The specifications, printed on page 71 of this issue, on their face look somewhat crude, but nevertheless innocent. In point of fact, the cloven hoof of ill-disguised commercialism protrudes from their raiment. This journal gladly acquits the committee that framed them of wilful guile as a whole, yet it certainly has managed to draw up a document that will lend itself readily to ends which its authors would hardly care to stand for were they plainly expressed. With malice toward none and charity toward all, this journal feels compelled to let the cat out of the bag and to show the dangerous issues that lurk in these mild-mannered specifications.

To go back a little, street arc lighting up to about the year 1898 was carried on to all intents and purposes exclusively by means of the familiar open arcs, of two general patterns, one taking about 9.6 amperes at 45 to 50 volts at the arc, the other about 6.8 amperes at the same pressure. The former was known to the trade as the 2,000 c.-p. or "full" arc, the latter as the 1200 c.-p. or "half" arc. Now, these candle-power ratings were a commercial fiction. The "full" arc gave a maximum candle-power of roughly 1,200 when operating normally, throwing it about 45 degrees below the horizontal, while the "half" arc gave somewhat more than half this light under the same qualifications. Both lights were subject to considerable fluctuations and were weak in rays near the horizontal, so that they gave excellent light near the lamp, but rather poor light at a couple of hundred feet away.

In 1898, the enclosed direct-current arc pushed its way to the front. This was usually a 6.6 ampere arc taking about 72 volts. This gave a smaller maximum than the old full arc, but a more even distribution and a steadier light. It required trimming only infrequently and therefore saved much in carbons and labor, but required to be run from arc machines similar to those already in use, which were rather inefficient. The new light was a pretty effective substitute for the old, lamp for lamp, and took about the same energy. In 1894, the National Electric Light Association, to simplify the situation, agreed to consider the then standard open arc to be of 2,000 nominal candle-power when it took 450 watts at the arc and the usual lamps construed this rating rather liberally. On the new lamps the wattage was liberal enough but the lower current density in the arc lowered the light to an extent that was not compensated by the higher voltage, and the chief gain was in steadiness and better distribution. The old wattage rating was tacitly retained. Had the matter stopped here disputes would have been few, but almost at once the alternating-current series arc at 6.6 amperes appeared, taking only about 410 watts at the arc. Now, alternating-current arcs are intrinsically considerably less efficient light producers than direct-current arcs and this alternating-current lamp was, in spite of a still further improved distribution, decidedly a less effective illuminant than the 450-watt arcs, open or enclosed.

Its gain to the station was considerable, both in trimming and in the substitution of very efficient transformers for rather inefficient arc machines, and therefore, by hook and by crook, it was pushed rapidly into use. Incidentally, it was a good thing for the manufacturers, since the stations had to secure a new equipment. It was not a bad light this 6.6 ampere alternating-current lamp gave, and when sold for what it was and not as an equivalent of the old "full" arc, nobody was the loser. Most contracts specified the lamp fully and fairly and the price was made satisfactory to the users. But later came a somewhat insidious tendency to push this lamp as an equivalent of the full arc, and here the trouble began. This attempt received a severe setback in the Colorado Springs decision of last winter, but at the recent convention, the National Electric Light Association attempted by a rider upon its committee report to resolve that three quarts make a gallon by extending its old 450 watt rating to cover alternating-current lamps. Now a "standard" alternating-current series lamp pushed to 450 watts by raising the current or voltage a little is distinctly inferior for the purposes of its use to the direct-current lamp of similar wattage. Look out for it! There is an alternating-current lamp, taking 7.5 amperes and about 500 watts which is up to the job of replacing the direct-current lamp, but it is seldom seen. Now, to side-step the difficulties of this situation, the committee resolved that instead of a watt or candle-power specification, street lighting should be sold by illumination, saying very truly that illumination is the end of street lighting and hence should be ultimately the goods delivered. Unhappily, illumination on the street is measured only with very great difficulty, so that it will produce unlimited litigation as the subject of contracts, while wattage or standard candle-power can be measured with relative ease.

Had the committee stopped here it would simply have endorsed a logical but somewhat impracticable method. It went on, however, to specify that the lamps should be rated solely by the light given at a distance of not less than 200 feet, that is, by the light given nearly horizontally, utterly irrespective of the perhaps very brilliant results over three-quarters of an acre or so of ground nearer the lamp. Right here, kitty pops out. A new form of arc, the so-called luminous arc, has been devised and is being introduced, which throws its maximum light very near the horizontal. It is highly efficient and, if measured in the way proposed by the committee, will enable an illumination specification at 200 feet distance to be met at an expenditure of little more than half the energy of the usual arcs, at the cost, however, of the brilliant effects produced by common arcs at shorter distances.

The luminous arc has many good qualities and will surely make a place for itself, but let it be sold for just what it is, and not by means of a disingenuous method of comparison. The luminous arc gives a capital distribution for street purposes, but one can ill afford to ignore the light given within 200 feet, since only within that distance of any commercial arc yet produced does the illumination rise to a value that is of much use for seeing purposes. The German Association of Lighting Engineers rates arcs on their mean lower hemispherical candle-power, thus taking full account of the total flux of light available on the street. This plan perhaps over-values light close to the lamp but it is far fairer than that proposed by the National Electric Light Association's committee and is not open to the objection of deliberately favoring a particular form of lamp at the expense of all others. When a proposition for changing the street lighting system arises it is up to those who guard the public interests to see that they are not persuaded to pay for light which they do not get. If highly efficient lamps are available they should be so freely used as to raise the general average of illumination instead of lowering it.

## Building a New City.

The industrial city which the United States Steel Corporation is building at Gary, Ind., to provide homes for the employees of the immense new steel mills under construction at that place, is being developed according to a broad general plan of greater scope than heretofore attempted for such a community in this country, if not in the world. The new steel plant will have 12,000 to 15,000 employees soon after it is started. The Steel Corporation also controls seven miles of water-front on Lake Michigan, extending from Gary to Indiana Harbor, which it is expected will be occupied almost entirely comparatively soon by the plants of the subsidiary companies or by those of allied industries. As a matter of fact, the American Car & Foundry Company has already decided to erect a plant in the vicinity of Gary which will give employment to about 3,000 men. Mill towns in this country, in which no outside interests are centered, have a general population of about five to each mill worker. On this basis, the population of Gary ought to be in the neighborhood of 75,000 within two years. The plans for the new town contemplate, however, that latter will be the residential center for the great industrial district which is certain to be developed at the lower end of Lake Michigan on account of the possibility of shipping iron ore by water from the mines around Lake Superior directly to the furnaces, and by the short haul from the extensive coal fields in Illinois and Indiana.

An idea of the scope of the municipal improvements and public service systems for this community, which it is expected will have an important part in the development of the new industrial district, may be obtained from a description published elsewhere in this issue of The Engineering Record. From this description it is evident that the best of modern engineering practice has been applied in the design and construction of these improvements and service systems. Many interesting and novel questions arise in planning and building such a city as Gary, and it might be considered that in this case the opportunity would be presented for improved and original methods of providing for urban population. At the same time, when the arrangements which have been developed for the benefit of existing communities are investigated, it is apparent that they cannot be varied to any appreciable degree without occasioning unreasonable cost, unexpected inconvenience, or the creation of new and undesirable conditions. The adoption of numerous innovations in the arrangement of different features of the public service systems at Gary has been practicable, nevertheless, and advantage has been taken of these possibilities in the work that has been done.

The expense of all the improvements which have been undertaken is borne entirely by the Steel Corporation and is added to the cost of the business and residence lots. These lots are sold subject to reasonable building restrictions that are designed to regulate the character of the city and of different districts in it. Contrary to the general conception, the Steel Corporation will exercise no further paternalism over Gary, which will not differ in its government from any existing city incorporated under the laws of Indiana, except that it is to be finished before being occupied. The outcome of providing such a complete, modern and substantial city as is being built under these conditions by the Steel Corporation for its employees will be of no small degree of interest. The undertaking is practically certain to be successful, nevertheless, because it should be borne in mind that before the new steel plant and other industrial plants which may locate in its vicinity can compete for labor, or for skilled labor, at least, with industries in settled communities a satisfactory place of residence must be provided in the practically barren sand wastes of northern Indiana.

## Notes and Comments.

A Building Partially Collapsed in San Francisco early this month, but up to the present time there have been no indications of a massing of technical experts and photographers to describe and illustrate every detail of the design and of the wreckage, although a number of men were hurt. Possibly, the fact that the structure was steel rather than reinforced concrete may be an explanation of the lack of interest shown in the accident by esteemed contemporaries. Just why they have spasms over similar insignificant accidents with reinforced concrete and disregard them when other building materials are concerned is a puzzling conundrum. The accident in this case was apparently due to the removal of bracing before enough rivets were driven; something likely to happen with any kind of construction when work is being driven at high speed and rigid inspection is not maintained. Every builder knows the danger and tries to avoid it, but foremen will occasionally take the risk of loosening up supports too early and a collapse sometimes occurs. It hardly seems likely that deep technical sermons will be preached on this accident or the use of steel on the Pacific Coast will be at all affected by it, but had it been a concrete floor that dropped what a fine stir it would have made in the trade press.

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THE POSTPONEMENT OF ROAD IMPROVEMENTS owing to the unwillingness of those paying for them to have their lives endangered by automobile scorchers was briefly mentioned last week. The subject is one that deserves a good deal of attention. The most destructive user of macadamized roads is unquestionably the automobile, and the time is fast approaching when some method of making the owners of motor cars pay a fair proportion of the maintenance expenses for highways will have to be rigidly enforced. The reasonable use of the roads by automobiles is a distinctly legitimate matter, but their unreasonable use is something entirely different. There is some difference of opinion between road engineers concerning the effect on highways of cars when running at high and at low speeds. Some engineers consider that a speed of 25 miles per hour or less does not work much injury, while others hold that the rate of speed of the car makes very little difference. It goes without saying, however, that a car habitually run at high speed covers so much more ground that it is more destructive than one which is run a shorter distance owing to its lower power, and on this account there is some justification for the tendency to tax cars according to their horse power rating.

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THE JUMP IN VALUATION of real estate wanted for public improvements is one of the interesting features connected with the prosecution of any large undertaking involving the condemnation of land. The taxpayers of the city of New York have become accustomed to such large payments for property needed for the public works that the enormous prices they are sometimes forced to pay do not arouse the general condemnation they should. The Board of Water Supply has evidently felt that the expenses for land connected with its works for bringing water from the Catskill Mountains will be so high anyway that every flagrant case of hold-up should be made public. Accordingly, one of the New York papers last week published an illustrated description of some property belonging to a man named Le Vino, situated on the line of the proposed Croton Aqueduct, for which the sum of $545,000 is asked. It is claimed that this property includes a railway, a valuable medicinal spring with improvements connected with it, and a natural park. All these things are shown by photographs to be mere fakes and the man is now the laughing stock of everybody who takes any interest in public affairs. It is to be hoped that such a course will be followed with every other flagrant attempt to extort ridiculously large sums from the city in connection with the new water works. There is nothing so much disliked by the man trying to pry open the public treasury as publicity, and the Board of Water Supply should continue its course of giving out illustrated information regarding these extraordinary properties for which enormous sums are demanded by their owners.

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THE BROKEN STONE INDUSTRY seems likely to develop before long in a way that will surprise a good many people. A good bank of building sand has long been recognized as a valuable asset, but it will not be long before a ledge of rock suitable for concrete and highway work will be equally prized. A few far-sighted people have already bought quarries and erected plants for crushing rock for sale as a commercial product, but the present price of broken stone in the vicinity of many cities indicates that more plants can be constructed without materially affecting the market. Any attempt to get out rock economically from most of the little beds developed for small pieces of work is entirely out of the question. The cost of quarrying and breaking the stone is quite high and the expense of transporting it to its place of use is generally equally high, so that it is often the case that a contractor can purchase broken stone from a large crushing plant many miles distant cheaper than he can obtain it from some small ledge in the vicinity. At present most contractors and dealers in broken stone zealously guard the cost of such material, but it is well established that the expense of quarrying and crushing stone is extremely low when the work is done according to a carefully arranged plan and with plant designed be somebody who appreciates not only the special conditions of rock breaking on a large scale, but also the importance of such items of expense as interest charges, depreciation and the like. It is reasonable to say that some of the neglected ledges in the more populated sections of the country will become as valuable assets as the undeveloped water powers which have but recently begun to attract attention.

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THE BOARD OF EXPERTS appointed by the Interstate Commerce Commission to investigate the value of safety devices on railways is thoroughly well qualified for its task. At the present time such devices, especially signal systems, are so closely associated with various commercial interests that independent investigations are very much needed. There is no question about the value of most of these appliances, but there is considerable lack of definite information concerning their field of satisfactory usefulness. There is also much misinformation floating about concerning just what safety appliances can accomplish. Oftentimes, after an accident, there is a strong feeling manifested in newspapers that sufficient or proper safety appliances were not at hand, whereas railway men will generally acknowledge in private conversation that the trouble was due to some employee's carelessness. This misapprehension has sometimes been unquestionably increased by attacks on the railroad where the accident occurred by men who have probably had their passes cut off in the past and wish to get even. The way in which newspapers hail them as experts seems to be some recompense for the fact that they no longer travel for nothing on roads where their transportation was formerly furnished free. The work of the Board of Experts is consequently of deep interest to the traveling public, and it is to be hoped that the Board will issue progress reports from time to time so that a knowledge of what it is doing may be had. Such investigations will clear up the uncertainty regarding about only three-tenths of the railroad accidents, and it would be a very good thing indeed if more railroad systems than the Harriman lines were to adopt the method of publicity regarding accidents which Mr. Kruttschnitt recently announced. On that system it is held that personal responsibility for accidents, whether officers or laborers, should be known to the public. It has been determined that there must be a closer observance of rules and greater respect for danger signals than is now obtained from employees. The method of accomplishing this which the officers of the company have adopted is to give the widest publicity to every accident. It will be recalled that this view was expressed in a signed editorial by Mr. Joseph Ramsay, Jr., published in The Engineering Record two years ago. Mr. Ramsay pointed out that until it is possible to secure laws which will make railway employees legally responsible for accidents due to their negligence or carelessness, it is hardly posible to insure much greater safety to travelers than is now afforded. So long as train crews can not be punished for accidents due to their carelessness, it is not worth while to expect any very great increase in safety from mechanical appliances except on roads which have not yet adopted them to the extent their traffic warrants.

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A NEW EDUCATIONAL SCHEME called a co-operative course in engineering has been established under the direction of Prof. Herman Schneider, dean of the College of Engineering at the University of Cincinnati. It is a six-year course, during which the students work alternate weeks in local shops throughout the scholastic year and full time in the summer. They have a week's vacation at Christmas and two or three weeks during the summer. The practical work at the shop is stated to be as carefully planned as the theoretical work at the university, and the students are paid about $2,000 for this work during the six years. The students who take the electrical course and work at the shops of the Bullock Electric Co. spend the first year in the foundry, the next year and a half in the machine shop, the next two years in the graduate-apprentice course, and the subsequent time in the drafting room and sales office. The aim of the course is, according to Prof. Schneider's paper before the Society for the Promotion of Engineering Education, not to make a so-called "pure" engineer, but to make an engineer able to take an important position in commercial work. The course is the result of an investigation which showed that a great majority of engineering graduates are employed in commercial production, whereas the present college courses were considered to contemplate only "pure engineering." The advantages claimed for this new educational course are that the extra two years give the student plenty of time to assimilate the theory he learns under the direction of his professors, the shop work has a valuable effect on the application of the theoretical studies he has carried through, the work is a change for the student and valuable as physical exercise, the student gains a knowledge of phases of the labor problem which he cannot obtain except by working in shops, and, finally, he learns to appreciate the importance of time in all commercial work. The course is an interesting innovation and the results of it will be followed with much curiosity, particularly if it is carried forward long enough so that the future careers of the graduates from it can be studied. In one sense, it is a return to some of the ideas which were firmly held when technical colleges were established in this country, for the attention given to shop practice is out of proportion to what is considered desirable in most colleges. If the object of a technical school is to turn out shop superintendents and managers, then it is safe to say that the course is likely to prove successful, for only those fitted by temperament and ability are likely to take its full six years of work. On the other hand it may be questioned whether so much shop practice is of any value to a good many engineers, for it seems to be pretty well established by experience that excellent designing engineers may be trained in the drafting rooms of establishments from students who have never had shop practice. It is safe to say that not one architect in a hundred can do a good job of plastering, yet all are perfectly competent to prepare the specifications and the drawings for such work. Probably verv few of the best designers of electrical machinery at the present time have the ability to themselves execute their designs in a shop.

# THE MUNICIPAL WORKS OF GARY, IND.

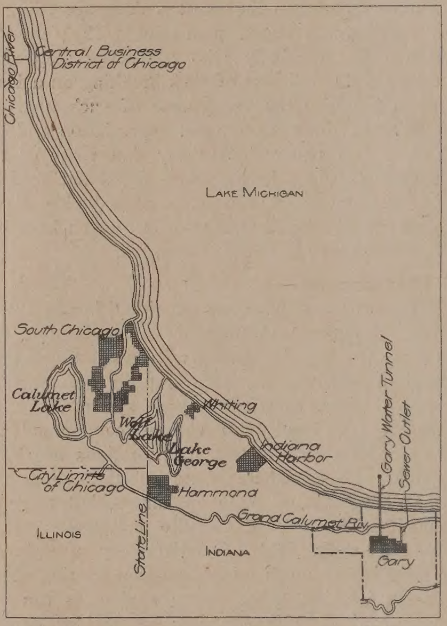
The city which is being built in connection with the new plant of the United States Steel Corporation at Gary, Ind., will have on the whole what are believed to be the most complete and extensive municipal improvements and public service systems that have ever been provided for a new community. The new steel plant will occupy a site about one mile square on the shore of Lake Michigan at the extreme southern end of the latter, 26 miles from the central business section of Chicago, and 12 miles from the South Chicago plant of the United Steel Corporation. This corporation owns seven miles of water front extending along the lake to the west from Gary to Indiana Harbor, the ultimate plan being to establish on this property the plants of allied industries, as well as those of subsidiary companies of the steel corporation. In fact, at least one large independent manufacturing plant employing 3,000 operatives has already been located in the immediate vicinity of Gary, the American Car & Foundry Co. having decided to erect such a plant.

The city of Gary is entirely distinct from the new steel plant, both in regard to location and ownership. The site is immediately in the rear of the steel plant, a sluggish stream, called the Grand Calumet River, separating them. The land on which the city is built, and, in fact, all of the land in that vicinity consists of pure lake sand, which lies in a series of alternate ridges and hollows, roughly parallel to the shore line of the lake. The tops of the ridges are 25 to 45 ft. above the water level of the lake, the general elevation of the hollows being 12 to 20 ft. above that level. The land was originally covered with a scanty growth of vegetation and small oak trees, for, except in some of the hollows, soil was almost entirely lacking.

The construction on such a site of a city which would provide a desirable place of residence for the families of the large number of mill operatives to be employed in the new plant, involved a great expense for preliminary grading before any municipal improvements could be made or public service systems installed. It was imperatively necessary, nevertheless, to afford homes for the 12,000 to 15,000 employees which will be required from the start in the new steel plant alone, and for the population which is expected to be drawn to the city by other industries in the vicinity. In fact, since these various industries will have to compete for workmen with settled communities in which all conveniences are available, the new city had to be a desirable and attractive place in which to live.

The town site was purchased in the first place by the steel corporation, by which it was divided according to what is considered to be the most satisfactory arrangement for an industrial town. Although the topography of the site of the city was very irregular, uniform grades for the streets and alleys were adopted, the streets varying from 19 to 25 ft. above lake level, with the grades of the building lots still higher, so that contrary to the general conception the new town is well above the lake. The adoption of these uniform grades necessitated several million cubic yards of sand to be moved to reduce the sand dunes and to fill the hollows and the waterways of the small sluggish creeks which traversed the site. As little of the sand had to be moved any distance, the grading has all been done with dump cars and horses, and with clam-shell buckets handled by traveling stiff-leg derricks with long booms.

The streets of the city are laid out on the gridiron system. A principal business street, 100 ft. wide, called Broadway, extends due south from a bridge which forms the entrance to the steel works through the center of the first subdivision of lots that has been made; a second business street, 80 ft. wide, called Fifth Ave., intersects this 100-ft. street at right angles near the middle of the subdivision. The lots on both these streets are 25 ft. wide and all face at the rear on an alley, 30 ft. wide. As all other streets in the subdivision are reserved for residences, the business houses will be concentrated on these two streets, the intersection of which is being made the commercial center of the city by the erection of large permanent business buildings, frame buildings being prohibited on these two streets. The residence streets are all uniformly 60 ft. wide, with alleys 20 ft. wide between each two streets. The blocks in the residence districts are 270x450 ft. and 270x630 ft. in plan, making the depth of the lots 125 ft., when the 20-ft. alleys are considered, the width of the lots being 25 or 30 ft. Space has been reserved in these districts for two recreation parks, one on each side of Broadway, the two being separated about ¼ mile. One of these parks covers an area of four city blocks, and the other an area of two blocks.



**Map Showing Location of Gary.**

Unlike many other similar communities which have been started in the vicinity of large industries in this country, the greater part of the lots along the two business streets in Gary were offered for sale with quite strict requirements, which are calculated to prevent any land-jobbing schemes and to produce a desirable business district, free from the objections so common to such districts in factory towns. The corporation reserved the balance of the lots on these streets, however, including a number of the more desirable business sites, and is erecting on them modern, substantial brick and stone buildings for banks, hotels, a theater, and so forth. The residence districts, on the other hand, being entirely reserved for homes for the employees of the steel corporation, will be free from business concerns of every kind. The houses, which are being erected by the corporation for its employees vary in cost from $2,000 to $15,000 each, and will be sold to the employees at cost. About 500 such houses are now under construction, one company having contracts for over $5,000,000 worth of these dwellings. A noticeable feature of these houses is that over fifty different designs were employed, but as no two houses in the same locality have the same treatment, the architecture of all is apparently different. The lots on the residence streets are wide enough and the houses are far enough back from the sidewalk line to present the appearance of a first-class suburban town. Cheaper homes and large boarding houses for the day laborers are also being erected in one section of the city, but the restrictions governing the erection and maintenance of these structures are such as to bring them far above the average.

*Street Pavements.*—The two principal business streets, Broadway and Fifth Ave., are paved with concrete; the remainder of the streets of the present subdivision are being paved with macadam. The concrete pavement on Broadway is 66 ft. wide between curbs and is flanked on each side by a concrete sidewalk, 17 ft. in width, which extends to the building line. The pavement is omitted for a width of 20 ft. along the longitudinal center line of the street to provide for the track structure of a double-track street railway which is to be built the length of the street. A concrete curb, 6 in. wide at the top, 12 in. wide at the base and 18 in. high, is placed along each side of this space for the car tracks, the front face of these curbs being vertical so the track structure will be entirely independent of the pavement. Fifth Ave. is being paved with concrete to a width of 46 ft. between curbs.

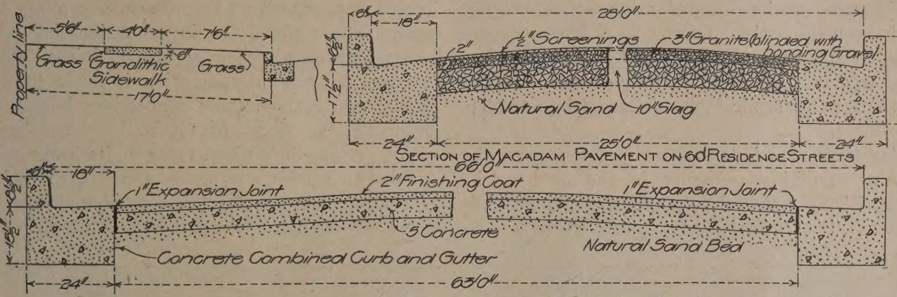
The concrete pavement which is being laid on these two business streets of the city has a total thickness of 7 in., made up of a 5-in. base course of 1:2:4 concrete covered with a finishing coat of about 5:7 mortar. The base consists of 1 part Universal Portland cement, 2 parts coarse sand and 4 parts crushed limestone ranging in size from ½-in. to 1-in. pieces. The finishing coat consists of 5 parts Universal Portland cement to 7 parts red granite screenings. The surface of this finishing coat is marked into 4½x9-in. blocks by grooves, ½ in. wide and ½ in. deep, this marking extending transversely across the pavement. Joints, 1 in. wide, which extend entirely through the pavement are placed across the street, 75 ft. apart, to allow for expansion and contraction, these joints being filled with asphalt mastic.

A combined concrete curb and gutter is placed along each side of the pavement, a 1-in. joint being left between the edge of the pavement and the curb and gutter. A true joint is placed in the curb every 6 ft. and a joint extends through both curb and gutter every 24 ft. Where the sidewalks extend out to the curb a 1-in. joint is made between them and the curb. The curbs are formed into steps at the street intersections, and at the corners special joints are provided in the curbs to prevent the latter being displaced or cracked. The street grades are arranged to carry the drainage to the center of the blocks, thus avoiding a high step at the street crossings.

The natural bed of sand on which the pavements are laid is merely leveled to conform to the grade of the pavement and the base course of concrete is laid directly on this natural sand bed. The concrete in most of the pavement that has been laid was mixed by hand, but a concrete mixer is used for the work that is now in progress. The finishing coat is laid immediately following the placing of the base course, in order to insure a bond between the two. The marking of the finishing coat is done before the latter has taken an initial set. This marking is done by men working on a traveling bridge which spans the pavement and runs on wheels on the gutters. Four men have marked as high as 6,000 sq. ft. in a day when working from this trestle.

In all, nearly three miles of the concrete pavements are being laid. The pavement on a portion of Broadway over 3,000 ft. long was laid last season; Fifth Ave. is now being paved for a length of nearly 1½ miles. The paving is being done by the Rudolph S. Blome Co., of Chicago, and is very similar to a large amount of such work which has been done by this company. Descriptions of some of these concrete pavements in Chicago built in this manner were printed in The Engineering Record for June 9, 1906.

The 60-ft. residence streets of the city are being paved with macadam to a width of 28 ft. between curbs, thus leaving a space, 17 ft. wide, between the curb and the lot line. This space is divided into a 7.5-ft. parking next to the curb, then a 4-ft. granolithic sidewalk, with a 5.5-ft. grass plot between the latter and the lot line.



Section of Macadam Pavement on 60' Residence Streets

Section of Concrete Pavement on 100 Ft. Business Streets

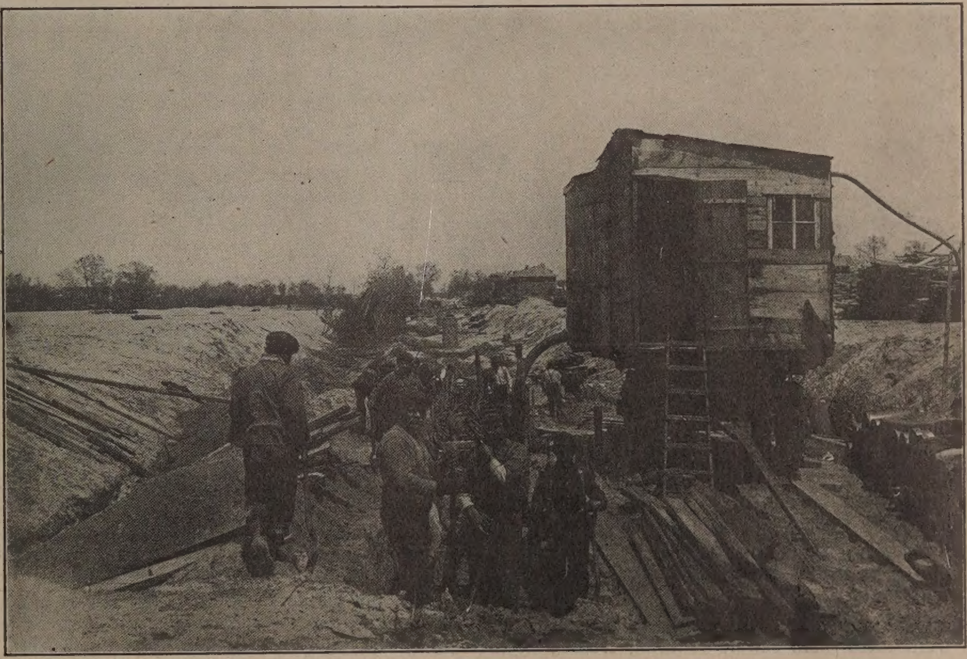
Sections of Street Pavements in Gary.

The macadam pavement is laid on a layer of slag which is 6 in. thick at the curbs and 10 in. thick at the center of the pavement. This slag is laid directly on the natural sand, and over it is placed a layer of 1-in. crushed granite varying in thickness from 3 in. at the crown of the pavement to 2 in. at the gutter. The voids in this layer of granite are filled with cementing gravel, the whole layer being thoroughly rolled and sprinkled as it is laid. A finishing course of ½-in. red granite screenings is spread over the surface to fill the voids which may appear in the macadam with use. The granite was chosen for the macadam instead of limestone on account of the glare from the latter, although the granite is much more expensive in this section.

*Water-Works.*—The water supply for the city is to be derived from Lake Michigan through an intake crib submerged in 40 ft. of water at a point 1½ miles from the present shore line. This intake is 12 miles southeast from the mouth of the Calumet River at South Chicago, which is the nearest considerable source of pollution. The water will be conveyed from the intake crib to a pumping station in the city through a 6-ft. tunnel 3 miles long. This tunnel will be driven 95 ft. below the level of the lake, in the hard clay which underlies the latter and the site of the city at that depth. Three shafts will penetrate to the tunnel, one connecting it with the intake crib; one on the shore of the lake, in which gates will be set to control the supply; and one at the pumping station, 1½ miles inland. The capacity of this tunnel is about 80,000,000 gal., and as the municipal water works are entirely distinct from the water-supply system of the steel plant, it will provide an ample supply for a population of over 300,000.

The two land shafts for the tunnel have to be driven through 50 ft. of fine sand and 40 ft. of clay. One of these shafts has already been sunk by the contractor for the construction of the tunnel, the Great Lakes Dredge & Dock Co., of Chicago, and work will be started at once on the tunnel bore.

The water-works pumping station will be placed at one corner of the larger city park. It will be constructed of heavy masonry according to a design that will render it an ornament to the park. The water will be drawn from the intake tunnel by large centrifugal pumps which will lift it to a water tower, 125 ft. high. This tower will be built of steel and masonry, conforming in architectural design with the surroundings. The pumps will be driven by electric motors supplied by a large electrical generating station in the steel mills, the original source of power being gas engines operating on waste gases from the blast furnaces. The combined capacity of the pumps will be about 20,000,000 gals., the plant being so arranged that under ordinary conditions water will be furnished at a pressure of 50 lb. per square inch, while in case of fire the pressure can be increased to 100 lb. per square inch.



Well-Point Pumping Outfit in a Sewer Trench.

The distribution system of mains is of seamless wrought-iron pipe, with unions forming the joints. The distribution system for the present subdivision is now completed and is arranged to supply every lot in this area. The gridiron system of mains was adopted, the different districts being cross-connected by large feeder lines, controlled by valves, which are so arranged that a broken pipe may be isolated quickly without interfering with the general distribution. The mains have an aggregate length of 22 miles, varying in size from the minimum of 6 in. for residence sections, to 30-in. for the main feeder lines. In order to avoid the necessity for tearing up the streets to make repairs or conneetions, the distribution mains are all placed in the alleys. The fire hydrants are, on the other hand, all located just inside the curb line of the streets, each city block being provided with four hydrants, one at the middle of each of its four sides. These hydrants are connected to the distribution mains in the alleys by pipes extending through the lots, so the pavement does not have to be crossed to reach them.

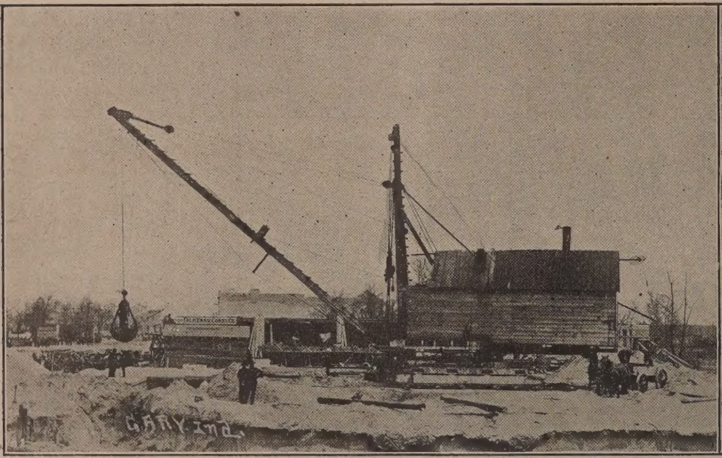
The whole water-works system has been designed so provision may easily be made for a supply for a considerable addition to the population and to the size of the city. The capacity of the pumping station may be increased readily and large feeder pipes radiate from the station to the borders of the present subdivision, in order that water may be furnished to additional subdivisions from this station.

The distribution mains were all laid to a depth of 5 ft. below the established grades. The irregular character of the site required a large amount of grading to be done in the alleys before the pipes could be laid. Grading and pipe laying were started in October last, and were carried on simultaneously during the winter, the work being now practically completed. As the grading was all in the fine sand, the pipe laying could follow it quite closely where necessary. Where the pipes were laid across low places in which the grade was to be raised they were placed on small wooden bents pending the filling of the low areas with sand.

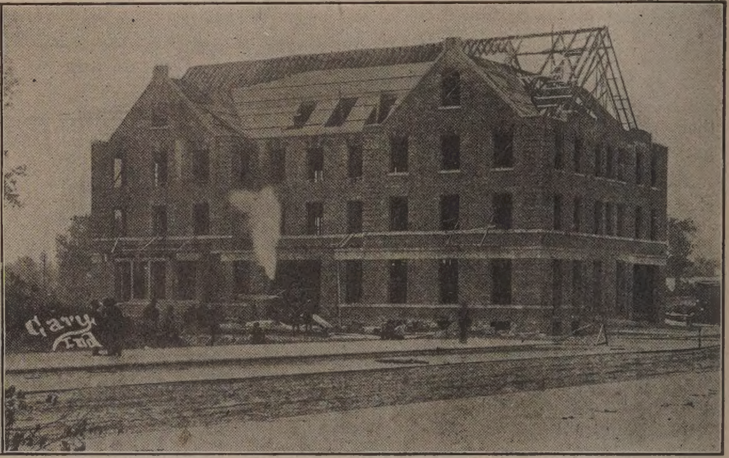
The intake tunnel will require some time to complete, so a temporary water supply is obtained from six 6-in. wells driven in the sand at the northwest corner of the present subdivision, in a locality isolated from swamps and all sources of pollution. These wells are all connected to one suction main which is extended into a temporary pumping station. This station contains a belt-driven centrifugal pump which will supply the distribution mains until the intake tunnel and the permanent pumping station have been completed; additional pumps will be installed in this temporary station, if required.

*Sewerage System.*—The ridges and hollows which make up the site of the city were so formed that the natural drainage was poor, the greater part of the rainfall being obliged to escape by percolation through the underlying 40 to 50 ft. of sand over the hard clay. The direction of ground water flow is toward the Grand Calumet River, which flows westward along the northern boundary of the town site, parallel with and about 1 mile from the shore of Lake Michigan, the river emptying into the lake at a point some 12 miles to the northwest at South Chicago. The flow in this river is very sluggish, its water level varying only slightly from the level of Lake Michigan. The reduction of the sand dunes to the uniform grades of the streets and alleys and the construction of an adequate sewerage system has entirely changed the natural surface conditions, and to a very considerable extent the ground-water level as well.

The sewerage system is designed according to the combined plan. Provision has been made for substantial growth in the areas on three sides of the present subdivision of two square miles, the steel plant being on the third side. The drainage of the present subdivision is carried to the Grand Calumet River by a 96-in. reinforced concrete sewer, which is sufficiently large to provide an outlet for a system for at least twice the area at present improved. An outline plan has also been made for draining 5 additional square miles through separate outlets. Several small sloughs in the hollows, which formerly carried considerable water at certain seasons, extended from the east to the west through the area that is being sewered and discharged into a small creek, called Gibson's Run, which emptied into the river at a point nearly a mile downstream from the outlet of the 96-in. outfall sewer. These sloughs are all being filled, and the water from them will be taken directly to the 96-in. outfall by a 72-in. sewer instead of passing through the improved area to reach the river through the small creek.



Traveling Excavator for Grading.



Type of Business Building.

From the junction of the 96-in. and 72-in. sewers a main sewer extends to the east and one to the west, these main sewers reducing from 5 ft. to 24 in. in diameter. The lateral sewers vary from a minimum of 10 in .to 30 in. in diameter. All sewers 24 in. or more in diameter are built of brick, except the main outfall. The smaller sewers are vitrified tile with cement mortar joints. The depth of the sewers ranges from 9 to 23 ft., the deepest sewer being placed in the business districts, or in localities which are likely to become business districts in the future. The lateral sewers are all placed at right angles to these mains, all the main and lateral sewers being placed in the alleys for the same reason the water pipes were so located. The gas pipes are also placed in the alleys, the sewers being at the middle of the alley with the water pipes 5 ft. from one lot line and the gas pipes, 5 ft. from the other. All house connections are made through the rear of the lots. Where catch basins in the street come at the middle of the side of a block parallel with laterals they are connected through the lots to the lateral sewer in the alley, one connection serving two basins. The only sewer connection under the street pavement is thus the single pipes from the catch basins on the far side of the street.

Until the town attains considerable size it is quite possible that the flow in the river, augmented by the large volume of pure water which will be discharged from the steel plant will give sufficient dilution to render inoffensive the discharge of raw sewage into the river. The entire sewerage system has been designed, however, with a view to the purification of the sewage as soon as conditions warrant it. The location of the purification works has not been determined beyond certain limits. At the same time these limits are such that the invert of the main outlet sewer can be constructed on a slight down grade away from the river so the dry weather flow will not reach the river, but will be pumped to the purification works from a sump some distance back from the outlet. During flood flows, though, this arrangement will not interfere with a free discharge into the river. The purification works will consist of septic tanks, followed by percolating filters.

*Construction of the Sewerage System.*—The natural conditions existing in the area to be drained have occasioned no small amount of difficulty in the construction of the sewers. The ground-water level was originally very nearly the same as that of a large portion of the surface of the land, although the sand dunes rose 15 to 20 ft. above it. Part of the first work done last season after the completion of main outfall sewer was to excavate a trench along the site of one of the main sewers, in order to drain the water from the hollows in the central part of the city and to lower the ground-water level. This trench was dug with a clam-shell bucket handled by a traveling stiff-leg derrick. It was carried to a depth of 15 to 28 ft. below the surface, the botom 4 to 5 ft. being finished by hand and very closely and heavily sheeted to hold back the fine sand through which the excavation was made; the top of the trench was also made as much as 50 ft. wide through the highest sand dunes. This trench had much to do with lowering the ground-water level, and with draining the central part of the town site, but the fine, loose sand on the surface of the ground drifted into the sheeted portion of it to such an extent that the lower part of it had to be partially excavated again before the sewer could be built.

All of the sewer trenches have to be very closely sheeted, and pumping has to be carried on continuously in the vicinity of the pipe laying. Messrs. Green & Sons, of Appleton, Wis., the contractors for laying the water pipe and the lateral sewers, have used a system of well-point strainers in connection with portable pumping outfits, which have proved especially valuable in keeping the trenches entirely free from water even where the ground-water level is practically at the surface of the fine sand. The trenches in which these outfits have been used vary from 2 to 4 ft. in width, and hav depths of 9 to 15 ft. They are in all cases closely sheeted, the sheeting generally being driven after the excavation has been opened to a depth of 2 ft. or more, unless the trench is at a point where the ground-water level is too near the surface.

The portable pumping outfits each consist of a triplex pump, belt-driven by a gasoline engine, the pump and its engine being mounted on a platform carried by the running gear of an ordinary wagon. One of these outfits is placed at the side of the trench where pipe laying is in progress. The pump has a twin 6-in. suction, each branch of which is attached to one of two 6-iin. pipes placed horizontally in the trench, one along each side. These pipes are in 20-ft. lengths, which are connected together by flanged joints. Every 2.5 or 3 ft. a 2-in. connection is made to these 6-in. pipes, each of these connections having two short flexible pieces of 1½-in. hose attached to them. A 1½-in. pipe carrying at its lower end a 1½-in. well-point strainer is attached to each of the hose couplings, the strainer being driven into the sand until it is below the grade of the sewer. The trench is generally opened in sections 60 to 100 ft. long, that is from the point where the excavation is just starting to the place where back filling can be done. In this way it has been found that the pump can remove the water so effectually through the strainers that the work is carried on entirely free from water in the trench, although much trouble is occasioned from water when the latter is drawn from the surface only.

The pumping outfit can be left at one place until 100 ft. of trench has been completed, as the 20-ft. lengths of 6-in. pipe are each fitted with a valve so those at the end where back-filling is being done can be cut off and carried forward to the point where the excavation is just starting. The siamese connections on these pipes are also each provided with a valve so any two strainers may be cut out of service. The well points are jetted down into the sand without any difficulty, and have been used repeatedly with scarcely no damage to them.

The water-works and sewerage systems were designed and are being constructed under the supervision of Messrs. John W. Alvord and Charles E. Burdick, sanitary and hydraulic engineers of Chicago. The main sewer, including about 3 miles of the deepest and most difficult work, is being constructed by the Nash, Dowdle Co., of Chicago.

*Gas Plant.*—A water-gas plant, with ample capacity to meet the demands to be expected from a city of 75,000, is being built. This plant and the system of distribution mains connected with it are modern in every particular. The main building of the plant, now practically completed, is at the north side of the city on the bank of the Calumet River. It is 63x141 ft. in plan and is built of red pressed brick, with sawed Bedford sandstone trimmings and a book tile roof, the latter being carried by structural-steel trusses.

Two gas-generating plants, each with a capacity of 300,000 cu. ft. daily, are being installed in the building by the Western Gas Construction Co., of Fort Wayne, Ind. In these generators live steam is passed through a bed of incandescent coke in which it is decomposed; oil is then admitted through a carburetor, the mixture passing to a superheater, where it is fixed in permanent form. The gas passes from the superheater through a scrubber, where the tar, ammonia and other impurities are removed, thence to a condenser to reduce the temperature, and finally through four 12x16x5-ft. Lloyd purifiers containing oxide of iron to absorb the sulphur impurities. The finished gas flows through an 84-in. American meter into a 250,000 cu. ft. double-lift steel gas holder in an above ground steel tank, a 10,000 cu. ft. relief holder also being provided.

The coke is dumped from the cars in which it is deliverd into a hopper under a track along one side of the building. The coke feeds by gravity from this hopper into a crusher which delivers to a bucket conveyor that elevates the crushed coke to a steel bunker over the generators, the latter being fed by gravity. The ashes from the generators are also removed by this conveyor. Two 75-h.-p. O'Brien boilers supply steam for use in the generators, for the mechanical equipment of the plant and for heating the building.

The distribution system of mains consists appromixately of 17 miles of steel pipe ranging in size from 4 in. to 12 in. The same difficulties encountered in laying the water-works mains had to be overcome in the construction of the gas distribution system. The freedom from danger of settlement in the sand in which the pipe is laid permit very accurate grades to be maintained, thus securing effective drainage for the system with a small number of drainage outlets. The pipes are all coated with asphaltum before being laid. As each section of the system is completed and before the pipe is covered it is tested at a pressure of 40 lb. per square inch, all leaks being carefully caulked. House connections are made to the lateral pipes in the alleys, with heavy saddles clamped to the street mains, thus obviating the necessity for cutting the pipe and inserting the usual tees.

The gas plant was designed by H. M. Byllesby & Co., of Chicago, and is being built under the supervision of that company, which will also direct the operation of the plant after it has been placed in service.

*Electric Lighting System.*—The present intention is to secure power for electric lighting from a large generating station in the steel plant. A distributing system of wires extending to all parts of the town will be provided, however, and current for power as well as for lighting will be available.

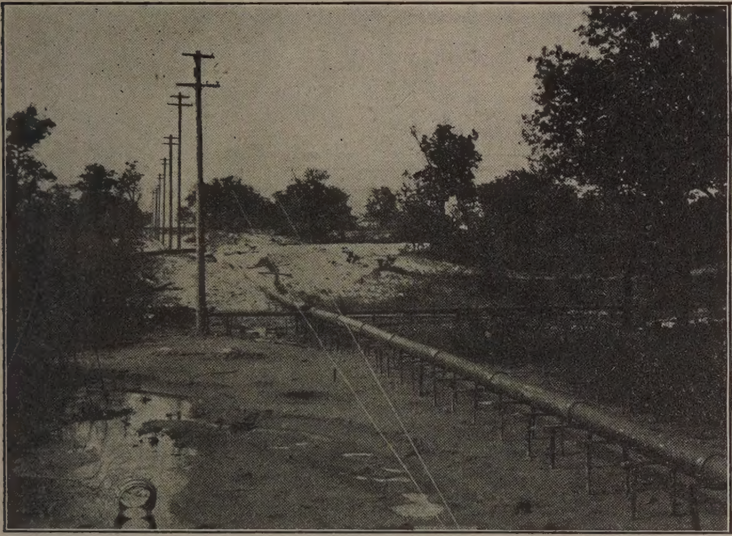
*Miscellaneous.*—The town site being entirely sand which contains no soil, except in a few places, it will be necessary to provide soil before grass or trees of any size can be grown. The valley of the Grand Calumet River in the vicinity contains a large amount of vegetable loam and black soil which can be brought to the land and distributed at a low cost. When the other improvements have been more nearly completed this work will be undertaken and a general endeavor will be made to cover the whole site with sufficient soil to produce good grass and trees.

The time consumed in building these comprehensive municipal improvements and public service systems, and in fact, the city itself has been remarkably short. Ground was broken for the first time in August of last year, when the paving work and grading was commenced. The construction of the water works distribution system, the gas plant, and many of the dwellings was started about the first of last November, but work on the sewerage system was not well under way until January of this year. The immense amount of grading required, involving several million cubic yards of sand to be moved, has been largely completed; the paving that has been undertaken will be finished soon; over 17 miles of the water distribution mains are laid and are being supplied with water from the temporary pumping station, pending the completion of the intake tunnel and permanent station; the gas plant and distribution mains will be ready for service before the end of the summer; the most difficult portions of the sewerage system are finished and work is progressing rapidly on the lateral sewers, and a large majority of the dwellings are nearly ready for occupancy, while a number of permanent business buildings are completed and occupied.

All of the municipal improvements that are being made at Gary will be paid for at the start by the steel corporation and are charged pro rata to the land, the charge being paid by the purchaser when the land is bought. When the improvements are all completed the steel corporation will relinquish all control of the property that has been sold, the restrictions in the deeds covering the sale of property, the unusually complete public service systems that are provided and other municipal improvements that have been made, being expected to preserve the character of the city well above that of the average mill town.

The population that may be expected in Gary in the near future has been variously estimated. Conservatively, it may be taken to reach 75,000 to 90,000 in five years. The new steel plant will employ 12,000 to 15,000 men, and the new plant of the American Car & Foundry Co., 3,000 more. The population of industrial towns in this country averages about five persons to each mill worker; based on this average, a population of 75,000 is evidently certain. The location of allied industries in this vicinity within comparatively short periods, and the expressed intention of the United States Steel Corporation to make its plant at Gary the one in which the expansion for western business, at least will be handled, give good ground to believe that the permanent and extensive improvements which have been undertaken to found a city of the better class under such adverse conditions are justified.

The construction of the new steel plant is being directed by Mr. G. G. Thorp, vice-president of the Indiana Steel Co. Mr. A. B. Neumann is chief engineer and Mr. W. P. Gleason, general superintendent, of that company. The town of Gary is being developed by an independent company under the general supervision of Mr. Thorp.



Water Mains before Grading.

View in Residence Section.

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A SAND ROADBED has recently been constructed by the Atlantic City & Ocean City R. R. to carry its electric line over a long stretch of salt marsh. A number of highways have been built in this neighborhood by confining a sand fill between lines of plank attached to posts, and this roadbed follows the same general plan. Two rows of posts are driven, one on each side of the 48-ft. roadbed, with their tops level with the surface. The inner face of each row carries planking for a depth of 5 ft. below the tops of the posts, leaving an open space of variable depth between the bottom course of plank and the top of the meadow. Sand is filled into the space between the rows of posts up to their top, as before stated, some of it running out at the bottom below the planking. Outside the row of posts on each side of roadbed, sand is filled in at its natural slope until it is within 2 ft. of the top of the posts; this fill acts to prevent the confined sand from slipping sidewise under the planking and allowing the track to settle.

## Standard Sand for Cement Work.

An investigation of sands for cement work has been made at the Iowa State College, Ames, Iowa, by Mr. M. J. Reinhart, to ascertain what the best sand should be like and how ordinary sands can be improved by screening or by adding the proper material to give the resulting mixture the least percentage of voids. From the account of the investigations presented by Mr. Reinhart before the convention of the Iowa Cement Users' Association these notes have been taken.

The sand used in the experiments was bank sand of exceptionally good quality, comparatively coarse and largely free from earthy materials and having about 30 per cent. of voids. All that failed to pass a No. 2 sieve was rejected. This was about 3 per cent. of the original sand and it was the grades from this size down that were used in making the mixtures.

The screens used in separating the sand into the various sizes were as follows: The No. 2, or two meshes per lineal inch, the No. 4, or four meshes per lineal inch, the No. 8, No. 16, No. 30 and the No. 50 screens. With the above screens a given amount of material was divided into the six graded sizes as follows: That which passed the No. 2 and was retained on the No. 4; passed the No. 4 and was retained on the No. 8; passed No. 8 and was retained on the No. 16; passed No. 16 and was retained on No. 30; passed No. 30 and was retained on No. 50; and finally that which passed the No. 50 sieve. In each case the per cent. of the whole was determined by weight and the voids in each separate part determined.

In determining the voids the following method was used: A cylindrical vessel holding about a pint was carefully filled with sand up to a horizontal line around the jar, and settled somewhat by shaking and tapping the sides of the vessel, but not tamped, and then weighed. The vessel was then emptied and a certain amount of water poured in, approximately equal in volume to the voids ÷ total weight of water × 100 per cent. carefully put back into the jar and water enough removed or added to cause it to stand just to the level of the line around the glass. The difference in weight between the vessel filled with sand and water, and the weight of the vessel and sand alone is the weight of the water required to fill the voids of the sand. Next the weight of the water required to fill the vessel up to the horizontal line was determined and by the following expression the percentage of voids was calculated: (Weight of water required to fill the voids ÷ Total weight of water) × 100 per cent. = percentage or voids. In all cases two determinations were made and the average taken.

Next, a properly graded sand was attempted, by putting the right amount of each grade of sand into the mixture. The weight of a certain amount of the coarsest material was found, and to it was added just enough of the next size to fill the voids. This gave a material made up of particles or pebbles which passed the ½-in. mesh screen and were retained on the ⅛-in. sieve. The voids of the large size was 44.2 per cent. of the small size 42.4 per cent., and of the mixture 38.0 per cent. To the mixture was then added enough of the third size to fill the voids, and so on down to the finest material, which passed the No. 50 sieve. The table shows the weight and voids of each material and mixture. The final mixture contained 24.4 per cent. of voids, a reduction in voids of nearly 19 per cent. as compared with the 30 per cent. of voids in the natural sand. This was the second mixture tried, the other by adding an excess of fine material each time gave a slightly larger per cent. of voids.

Next a mixture that would be practicable for improving sand was tried, on which by one screening of the sand the voids could be materially reduced. It is a generally known fact that if to ordinary sand fine pebbles as an aggregate be added a stronger mortar can be made from the sand, if mixed in a given proportion. So it was decided to add to the ordinary sand a certain amount of aggregate which passed a No. 2 sieve and was retained on a No. 16 sieve. To determine the correct proportion to add, a determination was made to find the per cent. of aggregate larger than that which passed a No. 16 sieve as well as the voids of the aggregate.

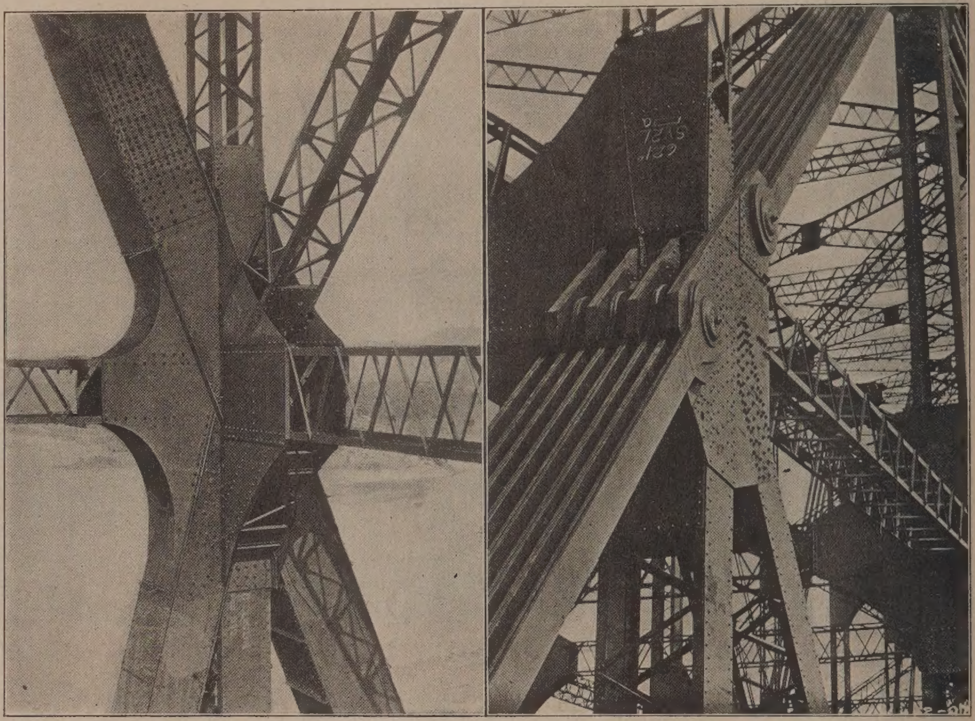
Properly Graded Sand.

| Kind | | | Quantity in Mixture | | | | |
|---|---|---|---|---|---|---|---|
| | | Percentage | Separate | | Combined | | P.C. of |
| Passed. | Retained on. | Voids. | lb. | oz. | lb. | oz. | Total. |
| No. 2 | No. 4 | 44.2 | 3 | 2. | .. | .. | 22.9 |
| No. 4 | No. 8 | 42.4 | 1 | 6.1 | .. | .. | 10.2 |
| No. 2 | No. 8 | 38.0 | .. | .. | 4 | 8.1 | .. |
| No. 8 | No. 16 | 43.4 | 1 | 11.4 | .. | .. | 12.6 |
| No. 2 | No. 16 | 33.5 | .. | .. | 6 | 3.5 | .. |
| No. 16 | No. 30 | 38.7 | 2 | 1.4 | .. | .. | 15.5 |
| No. 2 | No. 30 | 28.9 | .. | .. | 8 | 5 | .. |
| No. 30 | No. 50 | 38.1 | 2 | 6.4 | .. | .. | 17.6 |
| No. 2 | No. 50 | 26.9 | .. | .. | 10 | 11.4 | .. |
| No. 50 | ...... | 35.5 | 2 | 14.1 | .. | .. | 21.2 |
| No. 2 | ...... | 24.4 | .. | .. | 13 | 9.5 | .. |

It was found that 34 per cent. stopped on the No. 16 screen and that this material had 34.2 per cent. voids. Starting thus with a given amount of this coarse material (16 lbs.), the proper amount of natural sand to add in order to just fill the voids was calculated thus: Let $x$ = the amount of coarse material or aggregate in the sand. Let $y$ = the total weight of sand. Then $(16-x) \times 0.34 = y-x$, and $x = 0.342\ y$. Solving, $y = 10$ lb. In other words, to 10 lb. of sand was added 16 lb. of the coarser material, and this mixture contained 25 per cent. of voids, a reduction in voids of nearly 17 per cent. By the same method of determination the proper amount of aggregate to add to any sand or gravel might be determined.

In order to show the comparative strengths of mortars made from the three sands, the natural, the properly graded mixture, and the mixture improved by one screening only, tests were made, both for tension and compression. The specimens tested were ordinary briquettes for tensile strength and 6-in. cubes for compressive strength.

The mortars used in the tension briquettes were all 1:3 mixtures and the compression blocks were all made of 1:4 mortars. Three briquettes of each class were tested after seven days and six others were reserved, three to be tested at three months and three at one year. One compression block of each mixture was broken when seven days old and two others made at the same time and from the same mortars will be crushed when three months and one year old, respectively The mortar in which natural sand was used showed an average tensile strength of 367 lb. per square inch and a compressive strength of 1,889 lb. The mortar made with sand improved by one screening developed a strength per square inch in tension of 397 lb. (average) and in compression crushed under 2,611 lb. per square inch. The specimens made with properly proportioned sand showed an average tensile strength of 403 lb. and a compressive strength of 2,139 lb. The values developed in tension were quite consistent.



Main Diagonal Intersections, Quebec Bridge.

The results show the value of having the graded materials in a mixture of sand, and the fine material in the proper proportion to fill the voids in the larger aggregate. This was not a concrete but a mortar of about the consistency for cement blocks, tile, posts, etc. In the natural sand there was a deficiency of both the coarse and fine material, while in the other mechanical mixtures this fault had been largely overcome. In the former, mixed in a proportion of 1 to 4 the cement was insufficient to fill the voids, while in the latter case it was just sufficient, and hence the results.

Erosion of Steam Fittings by water in the steam was recently demonstrated by a test made by Mr. James F. Hobart. Two ¾-in. pipes were used, one known to carry water with the steam and the other dry steam. A flange union was put in each line and between each pair of flanges a diaphragm of thin sheet iron was inserted, pierced by a ⅛-in. hole in the center. Steam was then allowed to pass through both pipes for 6 hr. a day for 6 weeks. At the end of the time the unions were taken apart and the diaphragms removed. The hole in the disk exposed to dry steam was unaltered but that in the disk exposed to wet steam had been worn away so much that it resembled a key-hole.

## The Quebec Bridge Superstructure Details; Part IV.

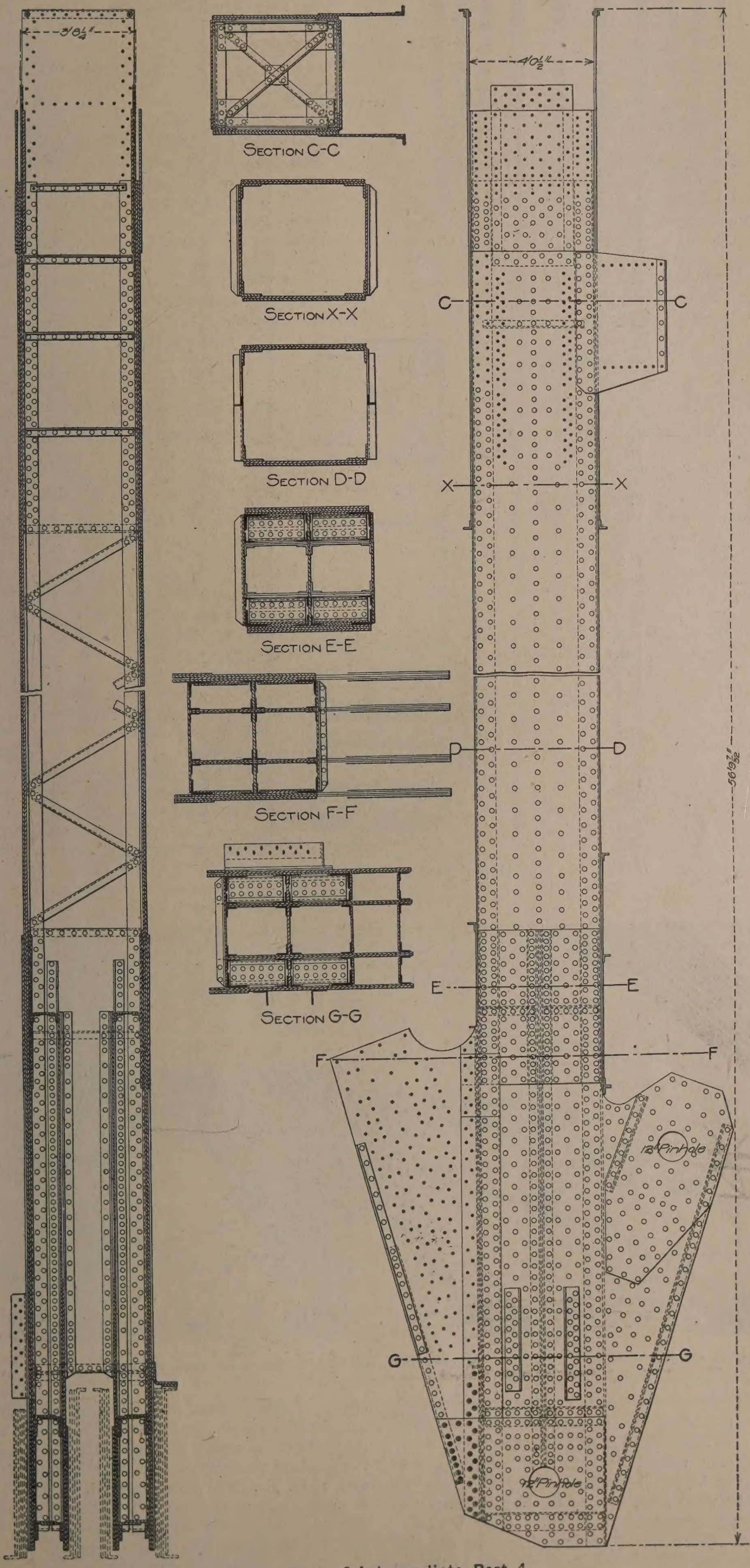
*Upper Part of Vertical Post 4.*—Intermediate vertical post 4, adjacent to the main post, is the largest of the vertical posts in the anchor arm truss and was shipped in two separate sections successively erected and connected by a field riveted splice 2 ft. above the center point of the completed member. The dead load stresses are uniform throughout the member, but the wind load stresses vary in the upper and lower parts, being somewhat greater in the former where the total maximum stress is 3,620,000 and is provided for with a gross sectional area of 174.3 sq. in. The total length of the post is 224 ft. from center to center of chords and the normal section is a 3-ft. 8-in. x 4-ft. rectangle.

The upper section of the post has a total length of 94 ft. over all and weighs about 92,000 lb. It is made of two built channels 4 ft. deep with their flanges turned in and latticed with angle bars in the spaces not covered by continuous flange plates. The channels are made with double 48x11/16-in. web plates 79 ft. 7 in. long riveted together and with pairs of 8x6x13/16-in. flange angles about 89½ ft. long, with double rows of rivets at about 6-in. pitch in each flange. Additional section is secured by a full-length 7x¾-in. flat riveted between the web plate and each flange angle. The joint between the upper and lower portions of this member is made with four flange and web cover plates, having in each end about two hundred ⅞-in. field-driven rivets.

Just above the splice the sides of the posts are stiffened and the rectangular cross-section is maintained by an interior transverse horizontal diaphragm made with a rectangular angle iron frame-work having intersecting diagonals shop riveted to the web plates and flange angles. About 33 ft. above the splice both flanges of the post are covered with a 50x½-in. plate 20 ft. long with one edge projecting beyond the flange angle to provide for the field riveted connection to the transverse bracing. The flange plates are stiffened with exterior 3x3-in. horizontal angles 3½ ft. apart and, completing the closed cross-section at this point, serve to distribute the transverse stresses uniformly between both main webs of the post.

The upper end of the post is connected on one side to 28-in. and on the other side to 30-in. top chord eye-bars, which, as already explained, in order to reduce the size of the pin and promote ease of fabrication and erection are connected to it with separate pins 14 in. in diameter, while a third pin 12 in. in diameter is provided for the connection of the diagonal member. For the proper packing of the chord pins each of them requires ten different bearings in separate longitudinal webs, the four center ones also providing bearing for the pin of the diagonal member.

To give clearance for the large eye-bar heads and other members converging at this point and to provide for a sufficient length of pin it was necessary to materially increase the dimensions of the post in both horizontal directions. This was accomplished by building up a series of longitudinal plates parallel to the web plates of the built channels and projecting beyond them on both sides. The upper end of the post web was connected by a single center transverse diaphragm projecting beyond their extremities to the end of the post and connecting them with the auxiliary web. Its construction virtually makes a 9 x 9-ft. cap about 17 ft. long, shop riveted to the main body of the post and integral with it. The longitudinal webs are reinforced to a maximum thickness of 5¾ in. by full-length side pieces riveted to them and serving as ribs to connect the opposite panels of eye-bars. Four of these webs are continuous at the foot of the

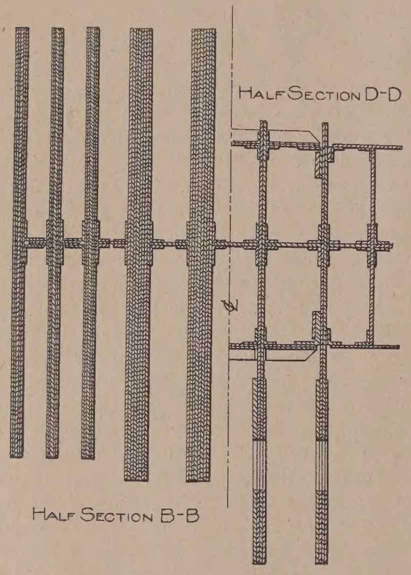


Lower Part of Intermediate Post 4.

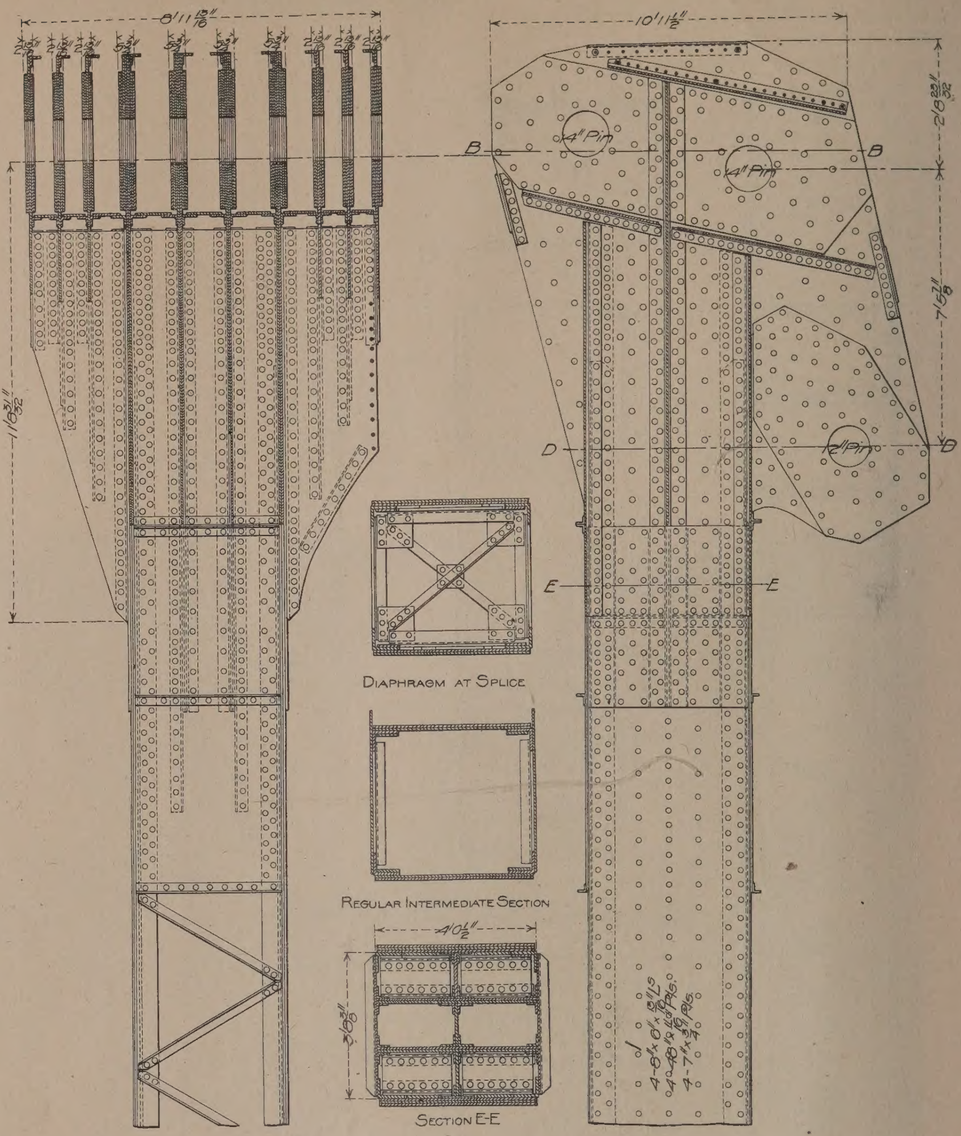
cap and receive the pins through the upper ends are exterior to the regular cross section of the flange plates. The remaining six webs post and engage the top chord eye-bars only. Wherever possible, the different pieces are riveted together but in some cases the connections have so little clearance that they have to be made with turned bolts, which are inserted through hand holes provided for that purpose. The lower part of the post is 56 ft. 9 in. long over all and weighs 75,000 lb.

The stress in different parts of the post varies on account of the different increments from the transverse bracing. The total maximum static and wind load stresses are 3,208,000 lb. for which there is a cross-sectional area of about 163 sq. in., diminished slightly from that of the upper part of the post by the omission of the 7-in. reinforcement flats under the flange angles. At both ends the flanges are covered with wide plates completing the closed rectangular sections everywhere except for a distance of 22½ ft. in the middle of the post where the flanges are latticed by zig-zag 3 x 3-in. angles. The flange and web cover plates in the splice are shop riveted to this section of the post and project beyond it to form double jaws receiving the web and flange plates of the next upper section, through which they are connected with about 220 field rivets. The angles are continuous through the full length of the post, but the web plates are cut about 18 ft. short of the lower end, where they are replaced by much wider plates projecting beyond both flanges to provide for the field riveted connection to the diagonal strut and the pin connection to the main digonal. These plates are about 9 ft. wide and have on one side about 150 holes for ⅞-in. field rivets to the inclined members. On the opposite side two parallel plates are riveted in and connected to the outer plates with diaphragms stiffening them to distribute the stresses from four bearings for each 12-in. pin. The 12-in. lower chord pin also takes bearings in the four web plates which are connected below with diaphragms made by pairs of 8 x 8-in. angles with flanges engaged.

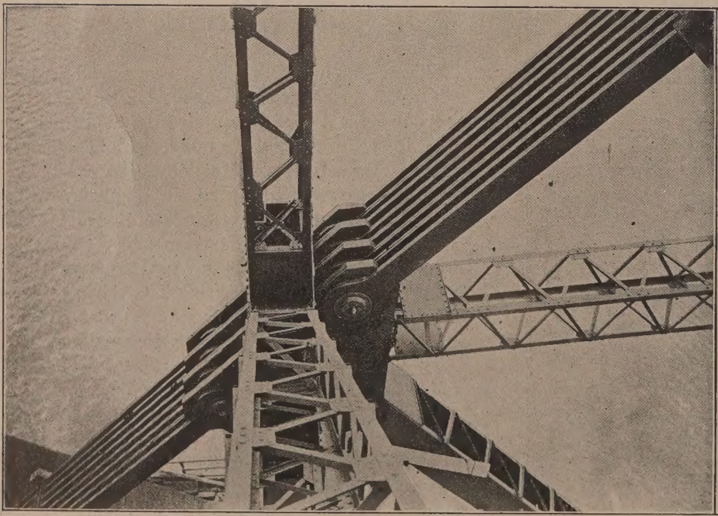
(To be Continued.)



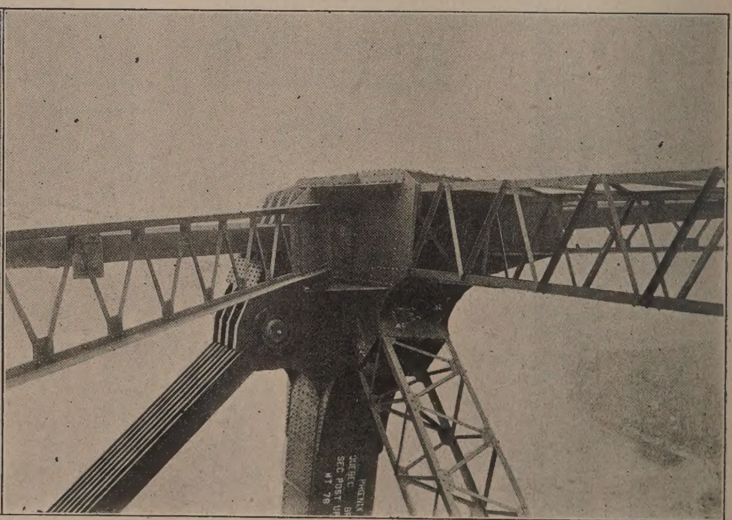
Sections, Upper Part of Post.



Upper Part of Intermediate Post 4.



Intersections of Main Diagonal and Sub-Vertical.



Intersection of Top Chord and Vertical Post.

## Pumping Water by Producer Gas Plant at St. Stephen, N. B.

Abridgement of a paper presented at the convention of the American Water-Works Association by Mr. F. A. Barbour.

St. Stephen is on the St. Croix River, which at this point forms the boundary of New Brunswick and Maine. On the opposite side of the river is Calais and upstream a short distance, are Milltown, Me., and Milltown, N. B. For twenty years these communities have been supplied with water taken from the river by the Maine Water Co. Increasing pollution of the stream had given rise to dissatisfaction with the water and on the expiration of the twenty-year contract St. Stephen determined to establish municipal works. Many surface supplies were investigated but in all cases the water was found to be so impregnated with vegetable coloring matter as to be unfit for use. Attention was then turned to ground water supplies. The first wells yielded only a limited amount, but finally water was found in large quantities. A test of several weeks' duration in the driest period of a dry year developed a supply of more than 2,000,000 gal. per twenty-four hours from a test well 6x8 ft. in horizontal dimensions and 13 ft. deep. The normal ground water level at this point of supply is 150 ft. above the principal streets in the town, thus greatly reducing the necessary pump lift. The Canadian Pacific Ry. runs within a few hundred feet, permitting economical construction of side track. It was accordingly determined to construct an open well, 20 ft. deep and 30 ft. in diameter, and to erect a pumping station at this point, lifting the water into a concrete reservoir situated on a hill some 1,500 ft. to one side of the main pipe line to town.

Up to the time the work was ready for receiving tenders the water company looked upon the municipal investigation as merely a piece of strategy to obtain better rates in a further contract but when fully convinced that an economical supply had been found and realizing that their present source must be abandoned, negotiations were begun by the company to obtain from St. Stephen the water required to supply the adjoining towns on the river. Since such an arrangement greatly reduced the cost of water per gallon this proposition was accepted by the authorities of St. Stephen, and it was finally agreed to furnish water at $24 per million gallons by Venturi meter measurement. The total daily quantity thus made necessary will run from 1,200,000 to 1,600,000 gal. Incidentally, it may be stated that with an actual pump lift of 135 ft. into the reservoir a pressure of 80 lb. at the hydrants when drawing ten standard fire streams, will be maintained in the principal streets of the town.

Steam, gas producers and electric power merited consideration for pumping. Electricity to compete in the pumping of water, especially where the transmission line is relatively long and a relay engine of some type is necessary for emergency use, must be obtained at less than three-quarters of a cent per kilowatt-hour. This could not be done at St. Stephen and the choice, therefore, narrowed to steam and gas producer plants. In relative reliability Mr. Barbour believes there is very little difference between these types of plants; in point of attendance there would be but little difference in the ordinary water-works station. The actual labor in handling the fuel is much less in such plants and the attendant has more time for other work. While the operation of producer plants is simple, it is more difficult at the present time to obtain attendants who appreciate the requirements and are in sympathy with this type of apparatus than in the case of steam plants. An engineer who has long been running steam engines if put in charge of a producer plant is apt to be prejudiced.

Believing that the choice at St. Stephen rested on the relative economy in first cost and cost of fuel, bids were asked on both steam and gas plants—the propositions to be based on two complete units, each of 1,800,000 gal. capacity in 24 hours and the bidder to name a guaranteed duty.

In order that the bids might express the actual relative value to the town, as far as possible, it was required that the duty should be based on the total coal used in a three days' test, engines to run eight hours and fires to be banked sixteen hours—all coal used in banking and all standby losses to be charged against the plant. Such a test is absolutely necessary in producer work, as no reliable results can be obtained in short runs and in steam plants, where boilers are included, the average ten-hour test is often very misleading. In the latter case if the run is started and stopped without drawing the fires the difference in amount of combustible on grates at start and stop, as manipulated by a clever fireman, will frequently involve an error of from 5 to 6 per cent. in the duty obtained. In producer work it is much more difficult to estimate the relative amount of combustible in the producer at any one time, and the period of the test run must therefore be extended long enough to eliminate, so far as possible, the personal equation and reduce the percentage of error. In power plants of different types the relative fuel consumption during hours of banking is most important. In the average high duty steam pumping plant running 8 to 10 hours and banking the remainder of the day, as observed by the writer, the coal used in banking will run from 20 to 30 per cent. of the total coal used or from 0.4 to 0.6 lb. per nominal boiler horse-power of banking. Such plants in actual operation usually develop a duty in hours of running equal to from 80 to 90 per cent. of that developed in a 10 to 12-hour duty test and, including banking, usually develop a station duty from 60 to 70 per cent. of the test duty. The short run test does not always develop he relative commercial or station economy of steam installations and in a comparison of steam and producer plants the standby losses must be taken into consideration. It is claimed that gas generators can be banked with less than one-tenth pound of coal per horse-power hour of banking.

Proposals were received on two steam plants and three gas producer plants. The first costs of the steam plants varied from 60 to 80 per cent. of that of the gas plants, but the duties guaranteed were more than correspondingly reduced. On the basis of using pea anthracite in producer and Nova Scotia bituminous coal for steam work, both at $5.00 per ton, there was no doubt but that the producer plants were much the cheaper proposition.

Some of the gas propositions were based on the use of centrifugal pumps, connected to the engine by silent chains, but the reduced efficiency, as estimated by the bidder, more than made up for the less cost of this type as compared with triplex power pumps. Apparently an efficiency of 60 per cent. was estimated in the case of centrifugal pumps and 70 per cent. with triplex pumps.

The proposition accepted included two Pintsch suction gas producers with necessary accessories, two 4-cycle single cylinder engines, and two double acting, triplex power pumps, each of 1,250 gal. capacity per minute. The contractors guaranteed a duty of 115,000,000 ft.-lb. per 100 lb. of pea anthracite coal having a thermal value of 13,000 B.t.u.'s per pound, with not to exceed 10 per cent. ash nor 8 per cent. volatile matters nor 2 per cent. sulphur.

The generators, which have each a rated capacity of 125 h.-p., are constructed of boiler iron, 12 ft. 9 in. high and 4 ft. 3 in. outside diameter, lined with fire brick and the space between fire brick and shell filled with mineral wool. The fuel is fed through a double-closing shotpouch hopper. This hopper is mounted on a cast-iron plate which is pivoted on a vertical pin and can slide on another cast-iron plate which is bolted to the outer lid of the producer. The lower plate has an aperture which leads to a conical fuel magazine in the upper part of the generator. This sliding lid, with ground joint surfaces, serves to permit of charging the generator with fuel without allowing the escape of gas or inrush of air.

The grates are of the so-called shaking basket type, especially adapted for the pea anthracite coal which this producer is to use. Large cast-iron doors with ground joint surfaces are placed above and below the grate on the two opposite sides of the producer, rendering the fireplace and ash pit readily accessible. A cast-iron pipe extends vertically from the ash pit into a concrete sump in the floor below the generator, which is kept filled with water and thus provides a water seal. In this way the ashes can be discharged through the ash door or through the water seal.

The gas after leaving the generator passes through the vaporizer, which is a cast-iron shell containing a number of vertical tubes, the space around the tubes holding water and the gas passing through the tubes on their way to the scrubber. The steam formed in the vaporizer is led through piping provided with the necessary valves to a steam jet, where it is mixed with air and led under the grate through the water seal pipe. This latter arrangement insures the air being admitted at the centre of the grate, resulting in an even distribution through the overlying mass of fuel.

The steam jet works under a pressure of less than 1½ lb. per square inch and is designed to secure a constant and uniform mixture of air and steam in excess of the requirements under any varying load conditions, the excess steam being carried away through a galvanized iron pipe to the outside of the building.

The lower part of the vaporizer is formed by a casting having openings leading to the scrubber and one to the relief pipe, which serves as a chimney during the hours when the engines are not taking gas from the generator. A cast-iron wall divides this lower portion of the vaporizer along a vertical line, extending from the top of this section of the vaporizer toward the bottom in such a way as to form, by the admission of water, a seal which, when the engine is stopped and the relief pipe open, prevents gas from the vaporizer entering the scrubber. The manipulation of this water seal is effected by valves provided in the piping.

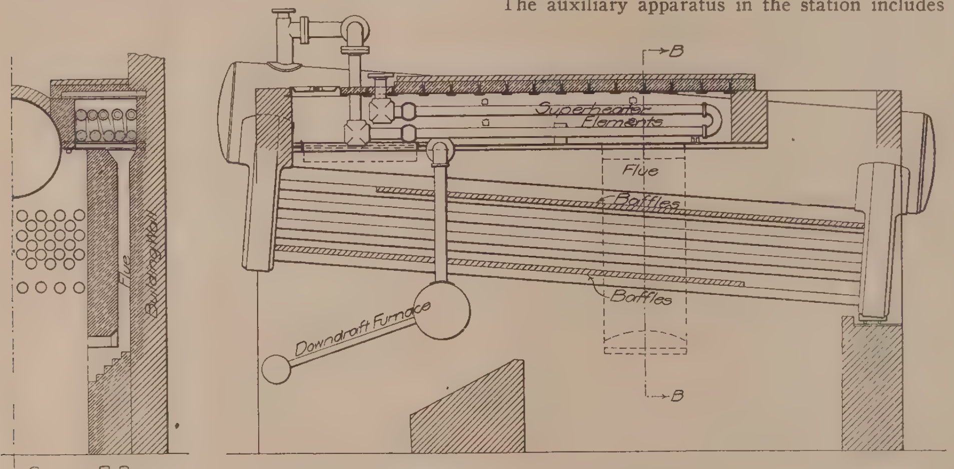
The scrubbers are made of boiler iron 12 ft. 8 in. high and 3 ft. 2 in. outside diameter and contain a removable grate for the support of the coke. The gas enters the bottom and leaves at the top, coming in contact in its passage through the scrubber, with water which is admitted to a sprinkler system attached to the scrubber cover. After passing the scrubber the gas is led by a vertical pipe to a cleaning pot, which serves to collect large particles of moisture which may have been carried over by the gas, and thence to the cleaner, which is a circular boiler iron shell, 5 ft. 6 in. in diameter and 32 in. high, fitted with two wooden trays, supporting layers of sawdust through which, by baffles, the gas is forced to pass vertically downward. The provision of this ample capacity in scrubber and cleaner is believed to be a valuable insurance against the passing over to the engines of dust and tar products, which lead to the minor difficulties in operation sometimes attributed to the use of this type of plant.

Each producer is equipped with a gauge board with water gauges showing the vacuum in the different parts of the apparatus. The piping is so arranged that either engine can be operated from either producer.

For blowing the producer when starting an air jet is provided, the air being taken from the compressor used for starting the engine.

The engines are 4-cycle, horizontal single cylinder, with one fly-wheel and outer bearing, with shaft extended to receive friction clutch by which the engines are connected to the pumps. The engines are nominally of 115 h.-p. and are designed to operate at 150 r. p. m.

The engine has a combination, starting, blow-off and relief valve. The valve proper consists of a casing containing three poppet valves, dividing the casing into three chambers. When starting, the levers that operate these three valves are brought into contact with an auxiliary cam by means of a special hand lever. The engine having been barred into position and the hand lever thrown to the starting point, compressed air is admitted into the cylinder, resulting in the piston, crank-shaft, lay-shaft and auxiliary cam moving, until by the action of this cam, the compressed air valve closes. On the return stroke of the piston the valve leading into the cylinder opens and also the valve into the vent pipe, thus allowing the compressed air to escape. This operation is repeated automatically until the engine starts to fire. The operation of blowing off while the engine is running, to remove impurities and excessive oil from the cylinder, is accomplished by throwing the hand lever in an opposite direction from that necessary for starting; the result being that the valve between the cylinder and vent pipe is open during a certain part of the explosion stroke.



Arrangement of Boiler Setting in Flour Mill.

Gas and air are admitted to the cylinder head valve chamber through a cast-iron pipe, divided by partition into two conduits, one for the gas and the other for the air, with provision for controlling the amount of gas and air in order to obtain the desired mixture. The air is taken through piping from above the roof of the building.

The exhaust gases are carried through one length of water cooled pipe and then through a non-jacketed cast-iron pipe to a combined muffler and heater below the floor of the engine room, from which they are carried to an exhaust funnel above the roof. The muffler and heater is a double walled cast-iron cylinder, with a section of tubes inserted between two headers, the gases passing through the pipes which are surrounded by water. By this muffler it is proposed to provide the necessary hot water for heating the building.

The engines are larger than necessary for the economical operation of the pumps, the size being determined by the intention of the authorities to employ these engines in the future development of electric current for lighting. The engines are connected with the pumps by means of a heavy duty friction clutch.

The pumps are of the ordinary triplex, four-stand, double acting type, geared to run 32 r. p. m. Rawhide pinions keyed to the shaft extending from the clutch, transmit the motion of the engine to the gears of pumps. The pump cylinder is 13 in. in diameter and the stroke 12 in. The two pumps have a common suction pipe, 18 in. in diameter, leading from the well with individual suction pipes 14 in. in diameter. The discharge pipes are 12 in. in diameter and connect with 14 in. force main leading to the reservoir. Check valves are provided in the discharge of each pump and also straightway valves in the discharge and suction pipes, thus permitting the entire isolation of either unit. Relief valves, with outlets piped into the suction, are also provided.

The auxiliary apparatus in the station includes an air compressor, driven by a Pelton wheel with water taken from the pressure main and returned to the well. The compressed air is piped to two receivers erected on the producer platform, each 32 in. in diameter and 6 ft. high. Compressed air is also employed in two stationary air-lifts, provided to raise or lower the exhaust valve of the engines. These lifts are attached to the engine foundations and facilitate any repairs or inspection of the exhaust valve or its mechanism.

The station building is of red brick and includes the engine-room, generator room and coal-shed. Above the engine room and connected with it by an iron spiral stairway is the office and bath-room. The generator room has a concrete platform, 11 ft. above the floor, and at the same elevation as the floor of coal-shed, thus permitting all coal to be transferred from the point of storage to the producers without lifting. A railroad siding permits the coal to be shovelled directly from the cars through the roof of the coal-shed. Care has been taken in the producer room to use concrete or brick throughout, both in walls and floors. Windows are provided in the wall between producer room and engine room so that the operation of the engine may be observed by the attendant, either when on the ground floor or the charging platform.

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Electric Towing was tried on July 13 on the canal of the Lehigh Coal & Navigation Co. at Mauch Chunk, Pa. A narrow-gauge track was laid along the towpath and on it a 10-ton electric motor truck was operated. This was connected by a hawser with a canal boat and dragged the latter satisfactorily.

## The Power Plant of a Small Flour Mill.

The power plant of the 400-bbl. mill of the Washington, Mo., Flour Mill Co. is an example of the economies which can be secured in a well-designed power installation of small capacity. The original power plant of this mill contained an 18x42-in. Corliss engine, operating non-condensing at 70 r.p.m., to which steam was supplied by two 48-in. by 20-ft. return tubular boilers. The latter had 33 sq. ft. of grate surface, or 1 sq. ft. to each 33 sq. ft. of heating surface, and were operated at approximately 100 lb. steam pressure. Under these conditions, on an average 43.5 lb. of coal were required to each barrel of flour that was produced by the mill. As this coal consumption was excessive, plans for reconstructing the power plant were made and carried out.

The two return tubular boilers were replaced by a single 100-h. p. O'Brien water tube boiler, having 1,003 sq. ft. of heating surface and 18.34 sq. ft. of grate surface. This boiler was equipped with an O'Brien down draft furnace, the upper grates of which consist of a row of 2-in. boiler tubes, inclined upward at a pitch of 4 in. to the foot, and attached at the front and rear to water drums connected with the main drum of the boiler. The latter is also equipped with a Foster superheater which is placed at the level of the drum of the boiler in a compartment at one side of the latter. A flue leading to this compartment is built in the side of the boiler setting and opens in the furnace just back of the arch. A part of the hottest gases are thus diverted through the compartment and over the superheater, which produces steam at about 100 degrees Fahr. above the temperature of saturated steam. The gases from the superheater pass out of the rear end of the compartment for the latter and mingle with those which have come up through the tubes of the boiler.

The cylinder of the original engine was replaced by a 12-in. high-pressure and a 24-in. low-pressure cylinder, making the engine a tamdem-compound machine, which is operated condensing. A Wheeler jet condenser served by a wet-and-dry vacuum pump was also installed, and a natural-draft cooling tower with a capacity of 2,700 lb. of water an hour was erected on the roof of the building, as the water supply is limited.

Tests made since the reconstructed plant was placed in service determined that on the average only 19.6 lb. of coal of the same quality previously used are required to produce a barrel of flour, or a saving of 120 per cent., as compared with the original plant.

The plant was reconstructed under the direction of Mr. William H. Bryan, consulting engineer, of St. Louis.

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An Insulating Joint to prevent electrolysis has been used in the 6-in. water service pipe that enters the power station of the Cleveland Electric Ry. It consists of a large wooden washer bolted between special castings forming adjoining ends of the service. Each casting has an 11-in. flange with eight ¾-in. holes by which it is attached to the service pipe and a 13½-in. flange with a dished face and eight 1⅛-in. holes to form the insulating joint. The wooden washer is a piece of hard maple boiled in paraffine and having a ¼-in. boss on each side, which fits into the recess in the face of the flange of the casting. The bolts at the joint pass through rubber hose and their nuts press on large fiber washers.

It may be added that there is a difference of opinion among engineers regarding the usefulness of any insulating joint. Fortunately, the engineering department of the Metropolitan Water and Sewerage Board of Boston has been carrying on investigations as to their value which will furnish definite information.

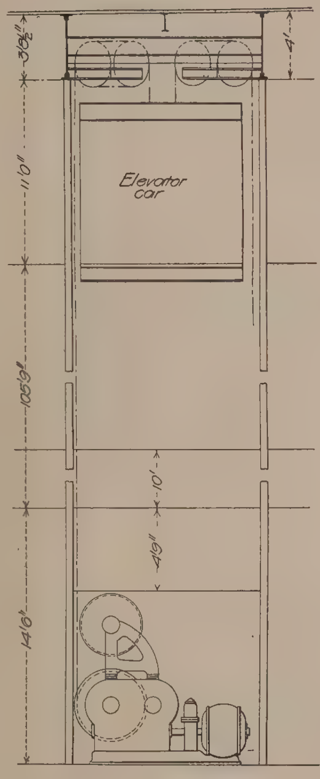
## The Elevator and Escalator Equipment of the New York Subway.

In the construction of the New York Subway the topographical irregularities of the upper portion of Manhattan Island caused considerable differences in elevation between the track grade and the surface of the ground at certain points, notably at Manhattan St., 167th St., and 181st St. on the Broadway Division, and at Mott Ave. on the Bronx Division. At 167th St., 181st St. and Mott Ave., the tracks are 100 ft. or more below the street surface, which renders access to the stations by stairways extremely difficult. At Manhattan St., on the other hand, the line is carried on a viaduct with a station at its centre where the grade of tracks is some 50 ft. above the street level. Electric elevators of large capacity have been installed in pairs at each of these three underground stations, and a duplex escalator at the viaduct station.

The electric elevator was selected so that the machine, as well as also the escalator, might be operated by direct current from the subway. As it is necessary to handle large crowds during rush hours, large elevator cars were required, necessitating special elevator machines and other mechanical features. The six machines have the largest capacity of any electric passenger machines installed in this country by the Otis Elevator Co., and are equalled in size only by the machines recently installed in new stations of the London Underground system. The cars are all 8¾ x 11½ ft., with a capacity of 8,000 lb. A load of 73 men and boys has been safely carried in one of the cars in a period of heavy traffic. Owing to this extremely heavy load, machines of the duplex type were installed, consisting of two large multipolar motors, mounted side by side on a single base plate to drive the hoisting drum through tandem worm-gear drives of the type usual in the Otis machine.

The installation of the equipments at 167th and 181st Sts. was attended with considerable difficulty owing to the location of these stations under sidewalks, with stair entrances at the street line, which prevented the projection of any structure above the street level to house the overhead gear. Furthermore, as it was desirable to have the upper landing as high as possible in the elevator shaft, it was necessary to minimize the space occupied by the overhead sheaves and supporting beams, which resulted in the location of the machines at the base of the shaft. Special overhead work was accordingly designed, which is particularly compact for the capacity for which it is designed. The upper landings in the shaft are within 14 ft. of the underside of the sidewalk vault light at 167th St., and within 15 ft. at 181st St., so that, with the total height of elevator cage of 9 ft., but 5 and 6 ft. overhead clearances, respectively, are obtained at the two stations. The supporting beams for the overhead sheaves were accordingly located 3½ and 4 ft. under the sidewalk vault lights, giving total clearances over the uppermost sheaves of 5 in. Details of the sheave supports are indicated in an accompanying illustration. The 30-in. sheaves carrying six ⅝-in. cables from both the counter-balance weights and the machines to the car are supported by two 15-in., 42-lb. I-beams, between which and two outer 12-in., 31½-lb. I-beams, are supported two auxiliary sets of 30-in. sheaves, each carrying two ⅝-in. cables from the machine drum direct to the counterweights. Owing to the width of the car and the limited overhead clearance, the use of single sheaves to pass the cables from the counterweights and the elevator machine to the car was prevented, necessitating the four 30-in. sheaves instead, two over the center of the car, one over the machine drum and one over the counterweight guides. The bearings for all sheaves except those over the center of the car, rest upon short 6-in. channels separated from the I-beams by 8-in. spacers, with flanges riveted to those of the lower channels and the I-beams. The large six-cable sheaves are so confined by adjacent beam supports that journal box bearings of the usual type were impossible, and the sheaves are accordingly arranged to turn on large 4-in. shafts or spindles passed through the large I-beams.

The cars of the 167th and 181st St. elevators are steel cages 8¾ x 11½ ft. outside measurement, designed for operation between corner guides in a hatchway, 10 x 11¾ ft. in size. The cases are of ornamental iron work, enclosed at the top and sides, and the floors are finished with interlocking rubber tiling. Each car has openings with folding gates at either end, and there is a 5-ft. double folding gate on both sides of the shaft at every landing, in order to facilitate the handling of crowds, for which purpose ample corridor spaces have been provided at every landing. The guides for all electric machines are 4x6-in. posts of yellow pine, bolted to 10-in. channels supported on the steel work of the shaft.



Elevator Mechanism.

The elevator machines at 167th and 181st Sts. stations are at the foot of the shaft in cellars with 10½ ft. clear head-room under the shaft pit for cars at the lower landing, but for the Mott Ave. station, the location was such that an overhead station building was permissible, allowing the elevator to travel up to street level with ample room for the overhead sheaves and supports. The building was accordingly arranged to accommodate the machines in the space above the shaft, the shafts themselves therefore extending but the necessary 4 ft. below the lower landing level. The machines used in this station are identical with those at 167th and 181st Sts., but the details of supporting structural work and arrangement of overhead sheaves is different. The cars are here 8½ x 12 ft. in size, traveling in a 9¼x13-ft. hatchway, over which the elevator machines are supported on four 18-in. I-beams spanning the hatch lengthwise. In order to prevent interference with the support beams, the guide posts on these cars are arranged at the side in the usual manner, the posts being here also of 4x6-in. yellow pine fastened to 10-in. vertical channels. The drums of these machines are so located that overhead sheaves are eliminated, except for the counter-balance weights, the car cables passing vertically downward from the inner face of the drum to the car fastenings, while those from the drum to the counterweights pass over sheaves at the rear to the counterweight slides. The cables extending directly from the counterbalance weights to the cars are carried by sheaves over the counterweight slides and an upper sheave mounted above the drum so as to clear the drum cables.

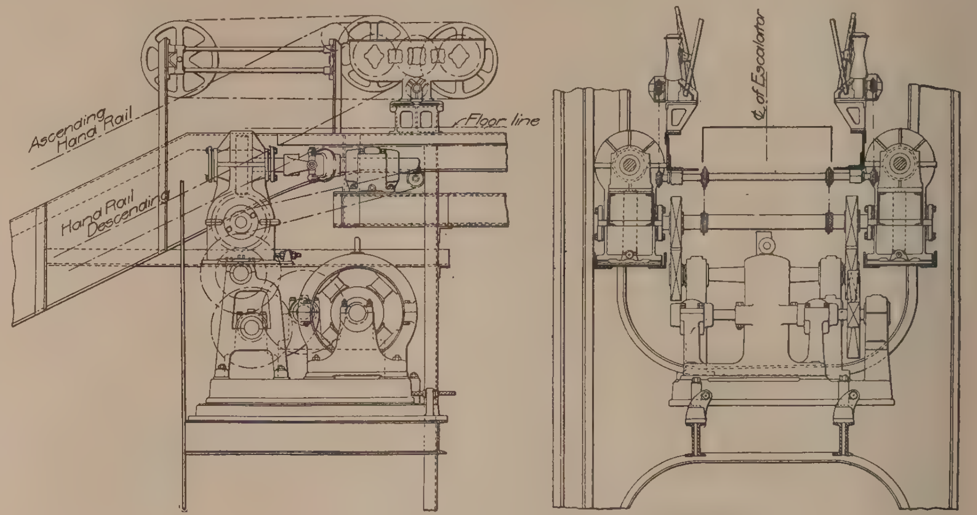
The elevator machines are all of the duplex tandem worm-gear type, equipped with two four-pole compound wound motors designed for operation on 500-volt current from the railroad propulsion system. The motors are specially designed with compound windings for rapid acceleration and the gear of the drive is proportioned for a car travel of 250 ft. per minute under all conditions of loading. The vibrating sheaves above the drum of the 167th and 181st St. machines automatically traverse in guiding the cable off the drum, the conditions of clearances and manner of running the cable permitting this to be done there without difficulty. The machines are all controlled from the cars by the latest type of magnet controller of the Otis Elevator Co., with duplicate control switches on either side of the car for convenience of operation from either doorway, and switch panels near the machines on which are mounted the solenoid switches, resistances and connections. These controllers have the usual features for utilization of the increasing counter electro-motive force of the motors, in starting, to cut out gradually the armature resistance and finally the series-field coils, by means of a series of magnets while retarding magnets are similarly used for slowing down. Special features of the control as applied to these cars are gate contacts by which the machine cannot be started until all gates in the elevator and hatchways are closed, the control circuits being made through contacts on all gates arranged in series, so that if any gate is left open the control circuit cannot be closed and the machines started. The machines are all equipped with the safety car switches, the slack cable switches, the limit switches and governors which are usual in electric machine installations.

The escalator installed at the Manhattan St. station is a moving stair of the traveling flight type, similar in general construction to those installed at the 23rd and 33rd St. stations of the Manhattan Ry., in New York, but differs in that it is of the duplex type, the flights being reversible and made to serve for both ascending and descending travel. As the station platforms are some 50 ft. above the street level, and it is necessary to elevate the passengers a distance of 33 ft. to a cross passage connecting both uptown and downtown platforms, it was desirable that the elevating mechanism be made available for travel in either direction. This was accomplished by the use of the one position treads of the Otis escalator construction which travel in an endless chain through both the up and down runways, offset arrangements at both top and bottom landings preventing interference of the returning flight with the loading and unloading landings as shown in the accompanying elevation detail of the escalator runways.

The general arrangement of the escalator involves an up-travel flight, 74 ft. long and a down-travel flight 80 ft. in length, including a 6-ft. level landing, midway in the run, to serve as an eye rest to the passengers looking down from the upper end of the long flight. The loading and unloading divisions are level, those for loading at both upper and lower levels being about 8 ft. in length, while those for unloading at both levels are approximately 15 ft. in length. The detail of arrangement of the unloading division with oblique wainscot rail follows the usual escalator practice. Moving hand-rails are also provided on both ascending and descending flights, which travel at the same speed as the stair flights.

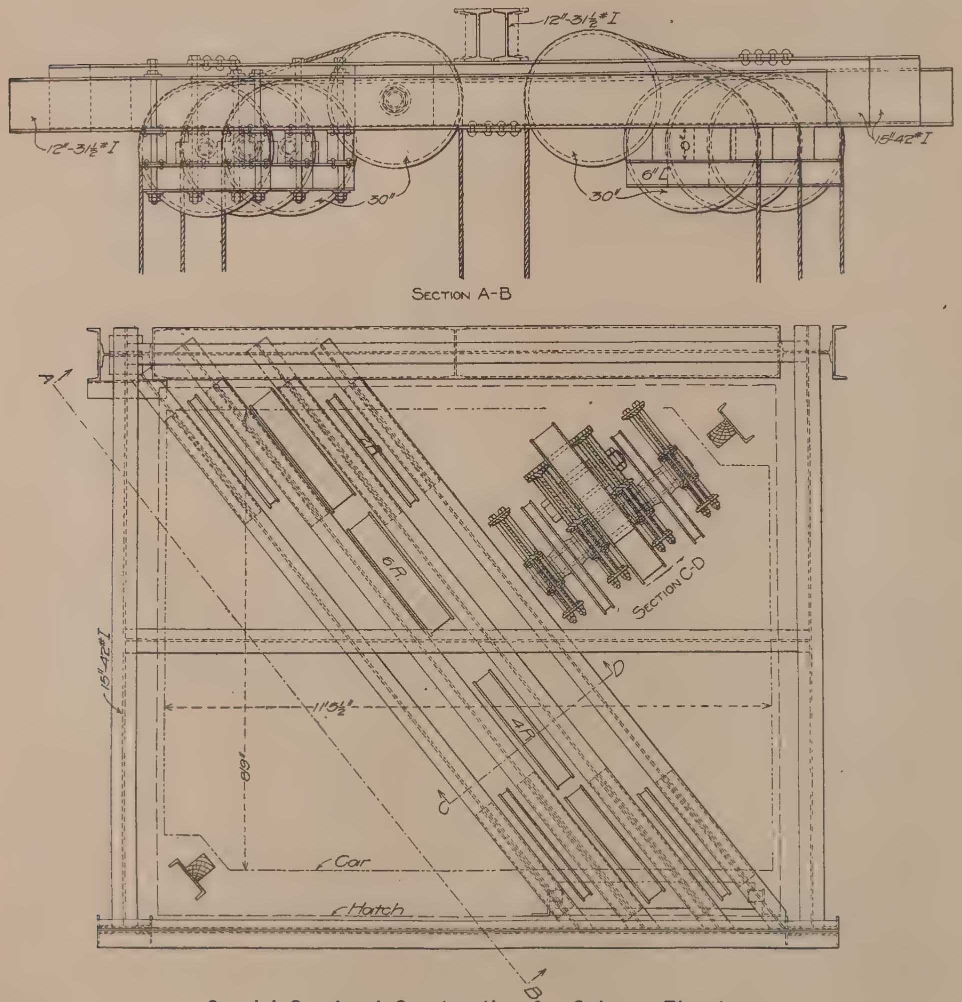
The escalator is driven by an intersecting mechanism which applies the driving force equally to both ascending and descending flights at upper points on the stairway run. It consists of a 60 h.-p. Otis motor mounted under the upper landing at the top of the ascending flight and arranged to drive through three gearing reductions, the shaft carrying the sprockets meshing in the flight driving chain. This gear is supplemented by a similar sprocket driving shaft under the loading landing at the top of the descending flight at the rear, which is connected to the ascending flight sprocket shaft by two 5-in. longitudinal steel shafts which are connected to the sprocket shafts at either end through spiral gearing. By this arrangement, the driving force, which amounts to an average power consumption of 25 h. p. is effectually equalized between the two halves of the endless chain of stair flights and the duty imposed on the sprocket and chain at either driving point lessened by approximately one-half. The driving gears are, however, both designed for ample strength to carry the entire driving strain if this should become necessary in case of emergency. The 5-in. interconnecting shafts between the two driving gears are of considerable length, approximately 35 ft., and in order to provide for possible deflections of the viaduct on which the mechanisms are supported, each shaft is connected to its spiral gear at either end through a universal joint. In practice it is found that the structure deflects under certain conditions sufficiently to throw the shaft out of alignment by as much as one inch. The spiral gears of the drive are entirely enclosed and fitted with an oil bath for lubrication and protection from dirt and dust. To the sprocket driving shafts of either flight there is connected by a chain drive a supplementary hand-rail driving mechanism of the endless cable type with rubber-covered hand grips. The rail for either flight is driven over pulleys carried in the upper surface of the banister and moves at a speed corresponding to that of the stair flight, returning within the boxing underneath the banister. Three sheaves above the driving mechanism for either flight carries the hand-rail, and by a turn around a third adjustable sheave provision is made for taking up slack in the cable.

The important feature of the escalator is its large carrying capacity. The flights are of unusually large size, each step being 18 in. in width by 4 ft. long, so that under conditions of maximum loading, three persons might be accommodated on each step. From actual practice it is found that under conditions of rush-hour travel an average of 2½ persons are carried per step continuously for considerable periods of time.



The Duplex Escalator Driving Mechanism.

With the normal speed of operation, of approximately 4,000 steps passing a landing per hour, the maximum carrying capacity of the escalator is, as determined by the average of 2½ persons per step, 10,000 persons per hour, for both the ascending and descending runs, making the total capacity of the station 20,000 per hour, as guaranteed by the builders. This is, moreover, accomplished by a continuous uni-directional movement of the apparatus and devoid of stopping and accelerations of the driving motor, as in the case of the usual elevator apparatus. While the escalator occupies more space than an ordinary elevator installation, it requires far less than that necessary for an elevator equipment of equal capacity and its advantage over the latter is obvious in view of the maximum carrying capacity of each of the above elevators at the above mentioned stations of approximately 1,000 persons per hour. An interesting feature of the escalator installation is the effect upon travel at that station. Aside from the fact of the general novelty of the escalator as a means of elevator travel, it has been found from studies of the actual station records of the subway operating company that the escalator station is one of the most popular stations on the line, and that a most decided preference is shown to it over other nearby stations of the subway and elevated lines in the city. In the hot summer months when the travel by way of all-stair stations decrease by from 10 to 15 per cent. over that of other times in the year, the travel at the escalator station remains constant or even above normal. The escalator at this station is operated constantly throughout the day and evening, and is shut down only from one o'clock to five o'clock in the morning of each day.



Special Overhead Construction for Subway Elevators.

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Plugged Cross-Ties have been used with marked success in large numbers by Chief Engineer Fredericia, of the Danish State Ry. A plain 1½-in. cylindrical creosoted plug of beech or birch is driven tight in a 1⅓-in. hole bored in the tie and the spike is driven in a hole bored in this plug. Worn-out ties plugged in this way have been found to give good service, as the rail seems to be held down with exceptional firmness and deterioration due to the pounding of loose rails is prevented.

## Suggested Specifications for Street Lighting.

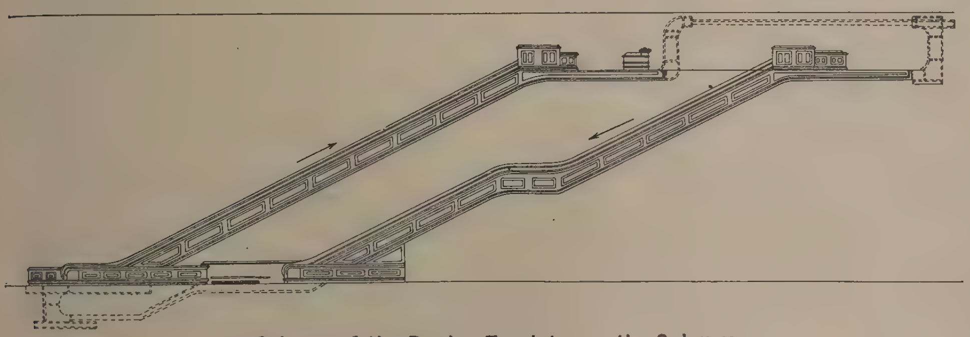
Report to the National Electric Light Association by a Committee consisting of Dudley Farrand, Chairman, A. E. Kennelly, Charles P. Steinmetz, Louis A. Ferguson and Paul Spencer. Comments on the report are given in the editorial pages of this issue.

In the year 1894 a committee of experts, appointed by the Association to consider the rating of arc lamps, reported at the seventeenth convention, then in session at Washington, a preamble and resolution which was adopted as follows:

"Recognizing the difficulty, if not impossibility, of measuring with any degree of accuracy the illuminating power of the arc lamp, and the great necessity for a more precise definition and statement of the obligations of the producer of electricity for illuminating purposes to the consumer thereof, be it

"Resolved, That in the opinion of this convention what is ordinarily known as a 2,000-c.-p. arc lamp is one requiring on the average 450 watts for its maintenance, the measurements being made at the lamp terminals, where no sensible resistance is included in series with the arc. In case such resistance is used, it must be excluded in the measurement of the voltage."

The rating of arc lamps on the basis of energy consumed, as set forth in the resolution, was then and would now be satisfactory as an equitable means of determining either a proper rate of charge or illuminating value for street arc lighting furnished by a company to a municipality, under the same conditions, but at the time of the adoption of this resolution there was in use in the United States no type of arc lamp other than the open arc, which, although of many makes and designs, gave approximately the same illuminating power for a given amount of energy. Wherever the rating adopted by the committee in 1894 has been employed in connection with open-arc lamps of the general type then in use, little or no difficulty has been experienced in the adjustment of differences arising from the interpretations of contracts.



Scheme of the Duplex Escalator on the Subway.

During the very year in which this rating was adopted, however, the commercial introduction of enclosed-arc lamps began, and within the past ten or twelve years the gradual displacement of open-arc by enclosed-arc lamps has taken place. The manufacture of open-arc lamps has practically ceased as a result of their inability to compete with the enclosed type, and manufacturers have devoted themselves almost exclusively to the latter unit quite recently. During the past four or five years there have been placed upon the market a number of distinct new types of lamps, which have been known by the general designation of "flaming carbon" or "luminous arc" lamps, some of which originated from American ideas, while others were imported.

The characteristics of the various lamps mentioned, taken either individually or grouped in classes, are so widely at variance in performance in the ratio between light produced and energy expended that the difficulties experienced by operating companies are greater now than they were in 1894, and the preamble then adopted is equally applicable to-day by reason of the introduction of these new devices.

In addition to the new types of arc lamps, there have also been placed on the market and are now offered for sale certain kinds of mercury-vapor or vacuum-tube lamps, which can be used for street lighting, as well as a considerable number of new incandescent lamps constructed of some form of metallized filament. Quite a number of the latter are already in use, with every prospect of their general introduction within a reasonable time.

Any attempt to compare the illuminating value of these latest forms of lamps, which are or may be used for street lighting, on the basis of energy consumed, is not only futile, but would be ruinous to the contracting company, for while the so-called high-efficiency lamps operate on a lesser expenditure of energy, they also give a larger volume of light. No reason can be given why a contractor should be penalized for giving more light than contracted for, after having made considerable investment for that purpose, simply because the number of watts consumed is less, notwithstanding that other items of expense and renewals may be considerably increased.

Your committee, after a most careful consideration of the difficulties to be met and for the purpose of establishing a definite basis, assumed: That, inasmuch as the lighting of streets by contract is a matter of illumination produced rather than of apparatus employed, the terms used in specifications should be in terms of illumination and not of energy consumed; that the individual lamp of each class should be the unit of number charged for; and that the average illuminating power of each unit should be comparable with and have a value equal to a known standard at proper relative distance.

The following report is submitted as the best provisional solution of the problem of street lamp specification that the unsatisfactory existing state of the science and art of outdoor photometry permits.

The committee considers that street-lighting lamps should not be rated in candle-power under contract specifications; because unless qualified as to the space distribution of the candle-power, such rating may be entirely misleading. The lamp may, by suitable reflectors, be made to possess a large candle-power in some particular direction or zone, and yet be very ineffective as a practical street illuminant. Consequently, the committee considers that the rating of street lamps in contract specifications should be in terms of the mean normal illumination cast at a considerable distance from the lamp, along the street which it illumines, i. e., the mean illumination thrown by the lamp upon a plane surface at a considerable distance from the lamp and supported perpendicularly to the rays.

The following specifications are drawn to cover the ordinary conditions of street lighting, and are recommended to replace previous specifications. such as those appearing in the Report of the Committee on Rating of Arc Lamps of the National Electric Light Association at the meeting of 1894, a copy of which is reported above:

(1) Under ordinary conditions of street arc lighting, with lamps spaced 200 to 600 ft. apart, specifications for street lamps should define the mean illumination thrown by the individual lamp, in position in the street, as measured at the height of the observers' eye and perpendicular to the rays, at some point not less than 200 ft. nor more than 300 ft. distant, along a level street, from a position immediately below the lamp, with all extraneous light screened off and with no reflection from surrounding objects not forming part of the lamp equipment.

The reason for leaving the horizontal distance flexible along the street within the range between 200 and 300 ft., is that a definitely specified distance such as 250 ft. might be unsuitable for the purpose of the measurement.

Within the horizontal distance in excess of 200 ft., the distance correction for the height of the lamp above the observer's eye is ordinarily unimportant.

(2) When using smaller units of light, such as series incandescent lamps spaced shorter distances apart, a correspondingly shorter distance from the lamp could be chosen in measuring the illumination.

(3) The lamp contracted for should give a mean normal illumination at the test point (selected as in Sections 1 and 2) not less than the illumination given by the stationary standard incandescent lamp of 16 c.-p. at 1/x of the distance. The said standard incandescent lamp should be a standardized seasoned lamp having a determined candle-power in a fixed direction.

(4) When the lamp tested fluctuates in intensity, a number of observations of the maximum normal illumination should be made at a distance of not less than 200 ft. horizontally from beneath the lamp, and the average of these measurements should be taken as the average maximum illumination. A similar number of observations of the minimum normal illumination should be made, the average of which should be taken as the average minimum illumination. The arithmetical mean of the said average maximum and minimum illuminations should be taken as the mean normal illumination called for in Section 1.

(a) When a reading-distance instrument is used for measuring the mean normal illumination at specified horizontal range, the average of a number of maximum distances at which a certain size of print can be distinguished may be called the average maximum distance, and the average of a similar number of minimum distances the average minimum distance. From these, the mean distance at which an illumination is cast normally, sufficient for distinguishing that size of print, can be determined. This mean distance must lie within the 200-300 ft. horizontal range specified in Section 1. In most cases the arithmetical mean of the average maximum and average minimum distances may be taken as the said mean distance with an accuracy sufficient for practical purposes. The illumination needed for distinguishing the size of print may be determined for each particular observer from measurements of the reading distance with the standard incandescent lamp referred to in Section 3.

(b) When a portable photometer is used at a fixed horizontal distance, such as 250 ft., the mean normal illumination of a fluctuating lamp may be obtained by taking the average of not less than 50 observations at intervals of not less than one-half minute.

(5) A reasonable number of lamps covered by the contract should be tested.

(6) For measuring the mean normal illumination of a lamp, comparison with the standard incandescent lamp may be made either with a

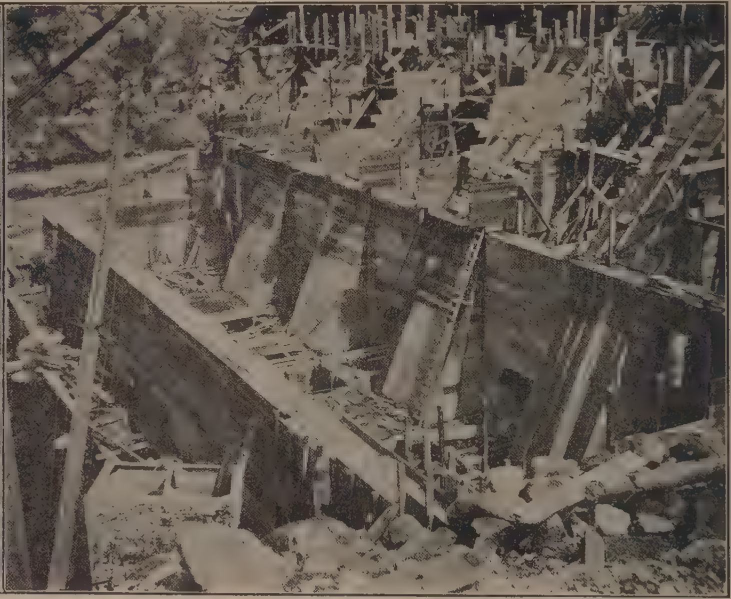
suitable portable photometer or with a reading-distance instrument, such as the so-called "luminometer."

(7) The unobstructed mean normal illumination must not be less at shorter distances than at the point of test.

(8) An approximate list of the mean normal illuminations thrown by street lamps of standard manufacture, at horizontal distances within the 200-300-ft. range, hung approximately 20 ft. above the level of the observer's eye, is given in the following table: (Data from which table is to be prepared are not yet completed. Table will be furnished later.)

Your committee during the consideration of this subject invited to its meetings and sought the advice and assistance of a number of the most prominent illuminating engineers and are lamp experts, and in that connection hereby expresses its appreciation for services rendered by Dr. Clayton H. Sharpe, Mr. Caryl D. Haskins, Mr. Frank Conrad, Mr. Carl Hering, Mr. Louis B. Marks and L. D. Howard Gilmour, and especially to Mr. W. D'A. Ryan for the quantity of data furnished to the committee for its use and the large amount of labor performed in the collection of additional data required in the preparation of the schedules.

Sand Pit and Gravel Sluice.



Dam under Construction, Nine-Mile Station.

Swamp Drainage on the catchment area of the Wachusett reservoir of the Metropolitan water-works has been resumed. As a rule, the ditches cut for the purpose have a board bottom 1 ft. wide, with 4 x 4-in. triangular wood strips rabbeted at the square corner to the edges of the board. The board is nailed to 2 x 4-in. cross pieces 2 ft. long and about 3 ft. apart, laid on the bottom of the excavation. The triangular strips make wooden sides to the ditch 3 in. high and serve as a footing for the stone paving on the slopes of the ditch. As the bottom of the excavation for the ditches is generally in water and the material is very soft, it is necessary to use some form of board bottom in order to preserve the grade of the ditch and afford a support for the slope paving, and the form of the bottom used facilitates cleaning the ditches. Where the ditches have steep grades and the ground is more firm, the bottom is also paved with stone; where the ground is stony, no paving is used. This type of ditch construction has been very successful in earlier swamp drainage operations in the Wachusett basin, resulting in a marked reduction in the color of the water.

## The Nine-Mile Power Station of the Spokane & Inland Empire Railway.

By H. Cole Estep.

Twelve miles below the city of Spokane, Wash., on the Spokane River, the Spokane & Inland Empire Railway Co. is constructing its new 15,000 kw. hydro-electric station, as described in this journal on March 2. The work of construction, which has been in progress since August, 1906, is now about half completed, and is in many ways in its most interesting stage. After several delays on account of floods and high water, the subaqueous work has been completed. To obviate as much as possible further delays caused by a rising river, a rather novel method of construction has been adopted.

The river is 250 ft. wide at this point, and the power house, which is built, as is usual in such cases, against the back wall of the dam, extends out to mid-stream, the generator room being 127 ft. long by 20 ft. wide.

The method of construction adopted consists in building the power-house half of the dam first, the foundation work being subaqueous. Then while the other half of the dam is being constructed, the river is diverted through temporary openings left in the base of the power-house dam for that purpose. When the whole structure is completed these temporary openings will be sealed.

To accomplish this the upstream face of the dam at the elevation of the generator room floor is left open, the upper part being supported by heavy cross walls located between each of the four generating sets. Between these cross walls are left four 20 x 30-ft. openings. I-beams bedded firmly in the cement at the top and bottom, spaced 12 in. apart, are placed vertically in these openings, forming a grid. When the power-house is completed and the coffer-dam thrown across the east half of the stream, the water will pour down through this grid and find its exit through temporary openings in the dam floor. After the east half of the dam is completed this grid will be sealed by driving sheet piling between the I-beams. This rather novel design has already proved its efficiency and will materially reduce the time and cost of construction.

The dam is being very thoroughly and substantially reinforced. The lower courses are tied together and stiffened by diagonal rods 20 ft. long, made of 1¼-in. twisted steel squares. The reinforcement of the upper courses consists of 20-ft., 1¼-in. twisted steel squares, laid in horizontal courses 2 ft. apart and tied together by short rods of ¾-in. twisted stock.

No penstocks are used, the wheel chambers being constantly under full head. The water is controlled by ordinary vertical lift gates located at the face of the dam. From each turbine the water is carried away by two draft tubes, each 8 ft. 6 in. in diameter.

A feature of the design of the dam is the hatchway provided for gaining access to each wheel chamber. This chamber, ordinarily under full head of water, is located between the sealed grid, mentioned above, and the main wall of the dam. At the top of the chamber the dam wall forms a corner, and in this corner, swung 45 deg. to the vertical, is fitted the 16 x 16-ft. hatchway. The hatchway itself, made of channel iron and reinforced concrete, is supported against the upward water pressure by removable girders. In one of the accompanying photographs the location of the hatchways is indicated by white crosses.

The plant will operate under a head of 60 ft. The flow of the river varies from 25,000 to 1,400 second-feet, the normal flow being about 6,000 second-feet. The river canyon is deep and wide enough to provide sufficient pond area to enable the plant to develop 15,000 kw. continuously. Two 3,750-kw., three-phase, star-connected Westinghouse alternators are to be installed immediately; one more is to follow before the end of the year, while eventually the plant will contain four 3,750-kw. machines. Each generator is to be driven by a 6,000-h.p., direct-connected, horizontal, parallel-flow turbine.

The switchboard gallery is located at one end of the generator room. Remote control will be used throughout, the main oil switches being each located in a separate fireproof compartment at the rear of the switchboard gallery.

Each generator is supplied with its own 3,750-kw. 2,300-60,000 volt, oil-cooled, three-phase Westinghouse transformer. The transformers are located in fireproof pits situated adjacent to the generators along the back wall of the dam. The generator room crane is used to handle the transformers. This brings out another of the features of the design. On account of the hatchways leading to the turbines, the transformers and the generators can be placed under the same crane runway; every part of the machinery is thus made exceptionally accessible, served by one main crane and can be moved rapidly and economically.

One of the causes contributing to the economical construction of this plant is the exceptionally fortunate location of the sand and gravel pit. At the site of the dam on the east bank of the river is found the finest natural deposit of sand and gravel that could be desired. The c here rises about 300 ft. above the river. The concrete mixing plant, in which are installed two steam-driven Smith mixers, is located on the hillside about 100 ft. above the river. From this point to within 100 ft. of the top of the cliff is situated a bed of fine, pure sand. The sand is transferred to the hoppers of the mixing plant in small, horse-drawn tramcars. Above the sand bed and extending to the top of the cliff is a deposit of clean gravel. The gravel is sluiced down to the concrete mixers by the common method used in hydraulic mining. On its way down the boulders are removed and diverted to a stone-crusher. By virtue of this natural gravity system of transportation and the close proximity of the material, the concrete at the spout of the mixers costs 13 cents per cubic yard, exclusive of the cost of the cement.

Except at prohibitive cost, the plant is inaccessible by rail. All the heavy machinery will have to be transported over the county road. Although the road is steep and crooked in places, the machinery can be moved in this way cheaper than by building a costly railroad spur.

The location is twelve miles from the center of distribution at Spokane and the electricity will be transmitted at 60,000 volts over this distance. The pole line is now completed and is being used temporarily for the transmission of electricity from Spokane for light and power purposes at the plant under construction. The transmission line follows the county road most of the way and is not on a private right-of-way.

The energy generated at the Nine-mile station will be used for commercial and street station purposes in Spokane and also for power on the extensive electric railway system of the Spokane & Inland Co., which operates 200 miles of standard gauge electric railway traversing the Inland Empire district of eastern Washington.

Messrs. Sanderson & Porter, of New York, are the contractors in charge of the construction of the Nine Mile Power Station. Mr. W. F. Zimmerman, of Spokane, representing the Inland Empire System, is the consulting engineer.

I-Beam Grid, Nine-Mile Station.

## Carrying Capacity of Reinforced Concrete Floor Construction.

By Messrs. A. E. Lindall and G. R. Heckle.

Many causes contribute to the diversity of opinion among engineers regarding the design and load-carrying capacity of floor panels, the principal ones being the variation in strength of material and class of workmanship, but more particularly the tests that are published with a view of exploiting the merits of a particular system, which tests are frequently executed in such a manner as to give entirely false impressions regarding the strength of the structure. It is a common practice to test a portion, or a strip of floor panel a few feet wide and judge from the load thus carried, the load which the whole panel could carry; or pile up bags of cement, sand or gravel and call each bag in height 100 lbs. per square foot, whereas the load averages more nearly 50 per cent. of this amount—that is to say, a pile ten or twelve bags in height will give about 600 lbs. per square foot of area. Materials such as pig iron, brick, pig lead, and so forth, unless special provision is made, may be suspected of carrying a portion of their load to the supports, by interior arching action.

The situation outlined is unfortunate, in so far that those who are interested, instead of being instructed are unconsciously misled, and until a great number of experiments have been made, placing the whole subject of reinforced concrete on a solid foundation of experimental data, this phase of the matter is really serious.

In justice to all who have made floor tests, it must be said that it is difficult to eliminate many inaccuracies. Laboratory apparatus can seldom be obtained; the heavy loads required to test to destruction full-sized floor panels can be secured in practice only by the piling up of a large number of comparatively small loads, probably giving a very fair uniform load, but uncertain, nevertheless, as regards its exact amount and point of application.

It is hoped that the following record of a test on a full-sized panel will be found generally interesting and useful, although subject to most of the criticism noted above.

The panel was built near the Intercity Viaduct, Kansas City, Mo., because the reinforced-concrete viaduct floor was under construction, and the convenience in securing material and labor very greatly reduced the cost of the panel. The foundation, however, was very poor, and the precaution that was taken to spread the footings under the corner posts was not sufficient to avoid serious settlement, and even cracks in the panel, as will be noted later.

The general plan and arrangement of reinforcement are shown in an accompanying illustration. The corner posts were made rather heavy for two reasons—to give as much continuity to the girders as possible, there being no surrounding panels as is the case in buildings, and to distribute the load on the foundation.

The reinforcement was corrugated high-carbon bars. The concrete was made of one part of Iola Portland cement, two parts Missouri River sand and five parts crushed limestone graded from ¼ in. to 1 in. in size.

The concrete was placed during cold weather in February and protected with manure—or in other words, subjected to the same unfavorable conditions that may obtain in practice. Tests were made sixty days later, on April 11, 12 and 13.

The slab was tested first, and in order to avoid loading the beams and girders they were blocked up, the idea being that the slab should be tested to practical destruction without injuring the beams, and then test the beams, blocking up the girders, and finally the girders. For loading material, cement sacks were filled with sand and twenty-five of these were weighed, the average weight being found to be about 113 lbs. per sack. This weight was then used to calculate the total weight by counting the number of sacks placed on the panel. The sacks were so placed as to load the area included between the center lines of the beams and girders, this area being 10x18 ft. in plan, or 180 sq. ft. To avoid arching action, a space was left between the piles in the center of the panel, as shown in one of the illustrations. Deflections were read in the middle of the panel, by means of a multiplying device, level readings were also made on the north corner posts. When the panel was only half loaded settlement began, cracking the outside beam on the north side, the cracks extending diagonally upwards toward the supports, or in the reverse direction to the ordinary diagonal tension cracks, the nature of these cracks being shown in an accompanying sketch. The total load, load per square foot, and the deflection in the middle of the panel are given in Table 1. Correction in the deflection had to be made because of the settlement, and this makes the deflection readings uncertain by perhaps as much as ⅛ in. An attempt to show by a curve the general relation between the load per square foot and deflection has been made in the accompanying diagrams, in which the deviation of some of the points from the average curve is probably due to causes enumerated above. At a load of 750 lbs., the loading was discontinued for the day, and an examination was made, which failed to show any cracks. The next morning, however, fine cracks about 3 ft. long were found in the under side of the slab, at right angles to the reinforcement, showing that the deformation had increased beyond that

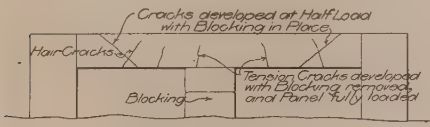
TABLE 1, TOTAL LOADS AND DEFLECTIONS.

| Slab. | | | Beam. | | |
|---|---|---|---|---|---|
| Total Load. | Load per sq. ft. | Deflection. | Total Load. | Load per sq. ft. | Deflection. |
| lb. | lb. | in. | lb. | lb. | in. |
| 40,000 | 220 | ⅛ | 132,200 | 367 | 3/16 |
| 60,000 | 330 | ¼ | 138,600 | 385 | ¼ |
| 105,000 | 580 | ⅜ | 154,800 | 430 | 5/16 |
| 113,000 | 630 | ⅝ | 171,200 | 470 | ⅜ |
| 118,000 | 655 | ¾ | 182,500 | 510 | 7/16 |
| 135,000 | 750 | 1 | 193,800 | 540 | ⅝ |
| 155,400 | 865 | 1⅛ | 205,100 | 570 | ¾ |
| 162,000 | 900 | 1¼ | 220,120 | 611 | 1 |

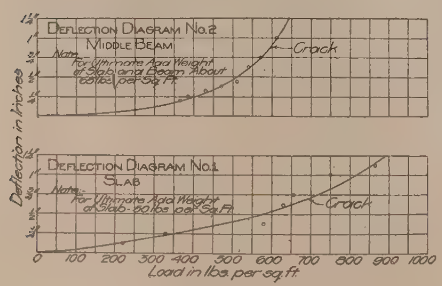
which the concrete could stand. Settlement became so troublesome that it was thought best to measure deflections from a string stretched from the under side of the girders; this would have been done in the first place only that it made it impossible to use the multiplying device. By the addition of another 100 lbs. per square foot the deflection increased ⅛ in., and by adding sufficient to make the total 900 per square foot, or the addition of about 40 lbs. per square foot more, increased the deflection another ⅛ in. As the deflection was rapidly increasing, and the cracks in the under side becoming more numerous and distinct, it appeared probable that the ultimate strength had about been reached.

One of the photographs shows the load at 900 lbs. per square foot over one full panel of the slab, which is one-half of the total floor panel, and gives a good idea of the amount of load required to produce 900 lbs. per square foot.

In arranging the test for the middle beam, part of the load was entirely removed from the panel and the balance distributed over the total area of 20x18 ft., or 360 sq. ft. The blocking was removed and a deflection of 3-16 in. noted, the total load being 132,200 lbs., or about 367 lbs. per square foot. Before the blocking was removed it was noticed that the beam, as well as the outside one previously noted, had a fine diagonal crack extending upwards toward the girder, probably due to unequal settlement, because upon removal of the blocking the cracks closed a trifle; in any event, it seemed to exert little influence on the strength of the beam, as it behaved in the ordinary manner upon the addition of load.


Cracks developed at Half Load with Blocking in Place
Hair Cracks
Tension Cracks developed with Blocking removed, and Panel fully loaded
Blocking

Cracks in Outer Beam.



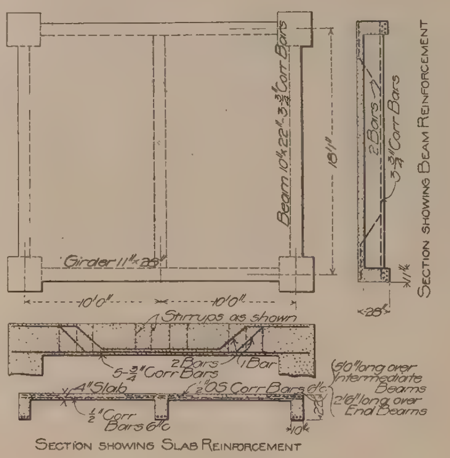
Load-Deflection Diagrams.

Referring again to deflection diagram No. 2 the relation between deflection and load per square foot can be seen. In this case the points noted agree very closely with the average curve. As the deflections were all noted with reference to the girders, the influence of the settlement was eliminated. At a load of 385 lbs. per square foot, two fine cracks appeared near the middle of the beam on the side adjacent to the slab previously loaded with 900 lbs. per square foot. These cracks extended less than 2 in. on the bottom from the edge of the beam, and showed no further development until a load of 430 lbs. per square foot, when cracks were found to extend entirely across the bottom of the beam. At 470 lbs. a fine crack appeared across the upper corner of the beam at the west end, intersecting the slab at about 12 in. from the end of the beam, and the girder the same distance down. The loading was continued with increasing deflections as shown on the curve until 611 lbs. per square foot was reached. The beam was allowed to stand over night with this load, and the deflection increased ⅛ in.; the cracks at this stage were about 1-16 in. wide at the bottom.

About 24,300 lbs. of the load was then taken off the two outside beams and placed directly over the central beam, with a space in the middle to prevent arching of the load. This left a uniformly distributed load of 544 lbs. per square foot over the entire panel; the 24,300 lbs. directly over the beam would be equivalent to 135 lbs. more, or a total of about 680 lbs. per square foot. If to this is added 60 lbs. per square foot for the floor and beams, the ultimate load at which the beam failed was approximately 740 lbs. per square foot. The failure took place along the crack previously noted as running across the upper corner of the beam. With the dropping of this beam, the slab sheared off at right angles to the beam for a distance of about 3 ft. on each side, about 24 in. from the girders, and the lower inside edge of the girder was broken off, exposing the bars in the bottom for a distance of nearly 3 ft.

Uniform Load of 900 Lb.

Loading to Prevent Arching.



Details of Reinforcement.

In order to obtain a full loading of the west girder, a false work was erected by making a cribbing of ties about 10 ft. from the girder and spanning the distance between the ties and the girder with old rails. The distance from the bearing points of the rails on the ties to the center of the girder was 9 ft. 6 in.

With 154,800 lbs. uniform load on the main panel and 50,000 lbs. uniform load on the false work, making the actual load on the girder 102,300 lbs., fine cracks appeared in the middle of the girder on each side of the center extending about one-half the distance to the bottom of the slab, the deflection being ⅛ in. On the failure of the center beam as previously noted, the inside edge of the girder was broken off at the center, exposing the bars, and a horizontal crack was formed in the outside face about 12 in. from the bottom and about 3 ft. long.

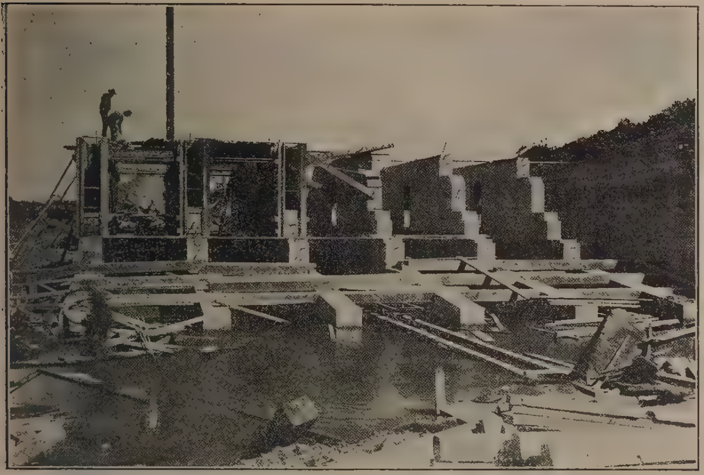
Approximately 219,200 lbs. were then placed directly over the girder, none of the load being outside of the center of the spans of the false work and the main panel, and a space being left across the middle of the girder to prevent arching. This load caused a ½ in. deflection in the girder, but no further cracks appeared. Estimating three-fourths of the total load as carried by the girder under test, the load on the girder represented a panel of 360 sq. ft. loaded 620 lbs. per square foot, and the total moment in the girder was approximately 5,740,000 inch pounds, using the formula 1-10 *wl*, in which *w* is the weight and *l* the length. This load was allowed to remain on the girder over the next day, or about 40 hours. The deflection was then found to have increased to ¾ in. and the cracks to have increased to about 1-16 in. at the widest point. The foundation had settled at one corner about 10 in. and at the other corners about 7 in., making any further loading impracticable.

It may be worthy of note that the floor slab and beam were designed to carry 600 lbs. per square foot ultimate load, and the girder about 85 per cent. of this load. These loads include the weight of the structure. On this basis, the slab carried more than 50 per cent., the beam 23 per cent., and the girder, at the time the test was discontinued, 13 per cent. above the computed breaking load.

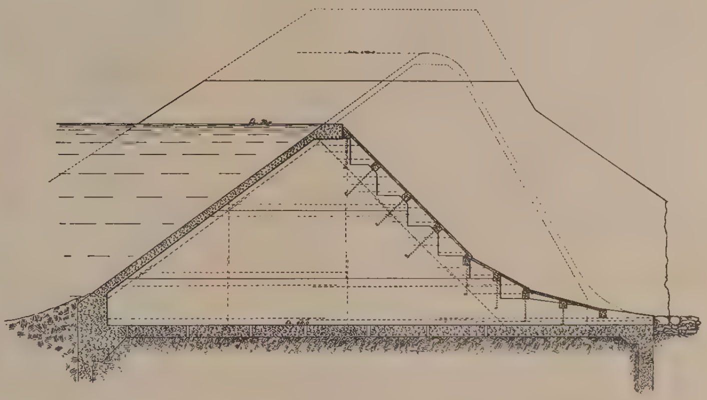
One or two points seem evident from the foregoing—that formulas frequently prescribed in building laws, such as 1-8 *wl*, 1-10 *wl*, or even 1-12 *wl*, do not even approximately represent the carrying capacity of floor slabs. This also applies to the formulas in which strips are assumed to carry loads in two directions at right angles to each other, because such formulas will show that about 90 per cent. of the load is carried in the short direction when one side is twice as long as the other. The assumption that a floor panel is an arch—a groined arch, perhaps seems unsound in view of the small rise that is possible in a 4-in. slab with a 10-ft. span, as well as the decidedly large deflection noted in the center. The opinion has frequently been expressed that little if any reinforcement is required in a floor panel, because of the restrained condition of the edges. While future investigation may reveal the desirability of radical changes in the method now employed in reinforcing floor panels, the writers wish to state most emphatically that a large portion of the under side of the panel tested was under very heavy tensile stress, made evident by the number of small cracks that appeared at right angles to bars, and the flaking of the concrete as the load approached the ultimate. Beams and girders, when incorporated in floor construction, agree very well with computed strength if computations are based on 1-12 *wl*—in fact there seems to be a comfortable margin of strength above this, which to a certain extent will take care of uncertainties in workmanship. Beams in end panels, where incorporated and made monolithic with exterior girders, have nearly the same strength as in interior panels. Floor slabs, while stronger than computed by the ordinary beam formulas, cannot be loaded indefinitely with "no appreciable deflection."

## The Upper Grays Dam, Consolidated Water Co., Utica, N. Y.

The following notes refer to a dam built under somewhat unusual conditions as to foundation and equally unusual requirements as to future extension. It is owned by the Consolidated Water Co., of Utica, N. Y., and is to provide additional storage for the water supply of that city. Investigation on the part of the company developed a good storage reservoir but with the severe drawback that the only available site for a dam was underlaid with foundations of clay, without either hardpan, gravel or ledge in sight. The clay was of a good quality and fairly tempered with sand. The difficulties of building on this foundation, however, were so great that it was tentatively abandoned and a new site selected where the foundations were adequate, but at a sacrifice of a large portion of the reservoir capacity.



Buttresses of Dam.



Section of Upper Grays Dam.

First Lift of Buttresses.

Part of Deck in Place.

At this stage the owners invited the Ambursen Hydraulic Construction Co., of Boston, Mass., to consider with them the situation and submit a design for a dam to be built on the clay foundation. They furthermore stipulated that the present height of the dam must be 30 ft. but with provision for future extension to a height of 40 ft., when additional storage should be required. This latter condition by itself was fatal to a solid dam on account of the cost of the 30-ft. dam being practically equal to the full cost of the 40-ft. dam when completed, assuming it was built at one time.

The borings indicated that the foundations could safely be trusted to support a working load of 1¼ tons per square foot with the clay confined against spreading. A broad floor was therefore laid out of such dimensions that the total load of the full-height dam under flood would be represented by a distributed pressure of 1.2 tons per square foot. The floor of course was amply reinforced in all directions and was pierced with a number of weep holes to relieve any upward pressure which might occur from accidental seepage and hillside springs.

Cut-off walls of reinforced-concrete were sunk in trenches at both the upper and lower edges of the dam, the former one being carried down 8 to 10 ft. until they intersected a bed of fairly good hardpan. The general arrangement is shown in the cross-section.

On this floor heavy buttresses were carried up, the downstream edges of which were stepped off as shown, with corrugated steel rolls left projecting from the vertical face of the steps so as to secure an ultimate bond with the extension when finally built.

The deck was carried up of a thickness proportioned, of course, to the ultimate height of 40 ft. plus flood, and finished with a temporary crest at the 30-ft. grade. Purlin timbers were then bolted to the nosings of the steps and on them was spiked a temporary apron of plank which served to carry over the ice and logs and at the same time protect the projecting rods from injury.

The bed of the river below the dam was paved for 30 ft. with a heavy body of boulders grouted together and finished to a cement surface.

The interior of the dam between the buttresses was fitted up for three measuring weirs, which enables the water supply to be carefully gauged and controlled.

When the dam is raised to the full height of 40 ft., the temporary plank apron will be removed and used as forms. The latter will then be bolted up to each side of the present buttresses and filled with concrete, with a bond secured by means of the projecting rods. The final deck and full apron will then be laid in concrete, as shown by the dotted lines, which represent the dam as finally completed. It should be noted, however, that the additional 10 ft. section is self-stable and would be permanent even if there were no mechanical connection between it and the lower section. The use of the junction rods is obvious and cheap and is at least a satisfaction to the mind if of no very marked utility.

The dam was finished last fall and has been in successful service for some six months. This construction opens up new possibilities both in respect to dams on soft foundations and in respect to providing for future increase of height.

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Two Building Collapses recently occurred in Philadelphia which were probably due to careless or negligent building methods. On July 13, while a gang of Italian and negro workmen were tearing down an old brick building four stories high, the floors collapsed and a number of men were injured, some fatally. The collapse was caused by overloading the second floor with brick from the third and fourth stories. The other accident occurred on July 10, and was the collapse of an incomplete reinforced concrete building on account of the premature removal of the forms, before the concrete had hardened. Several lives were lost.

## Completion of Grade Rectification in the Battery Tunnel, New York.

The rectification of the minor irregularities in the alignment of the twin tubes of the Battery tunnel has now been completed. As described in several previous articles, these irregularities were of a secondary nature, due to divergencies in the movement of the heavy tunnel shield through soft material and were corrected by comparatively small elevations or depressions of the roof and invert so as to cut out the summits of the line of divergence and distribute the deviation over a longer grade, providing for smooth track and preserving the minimum clearance of 8 in. for the cars.

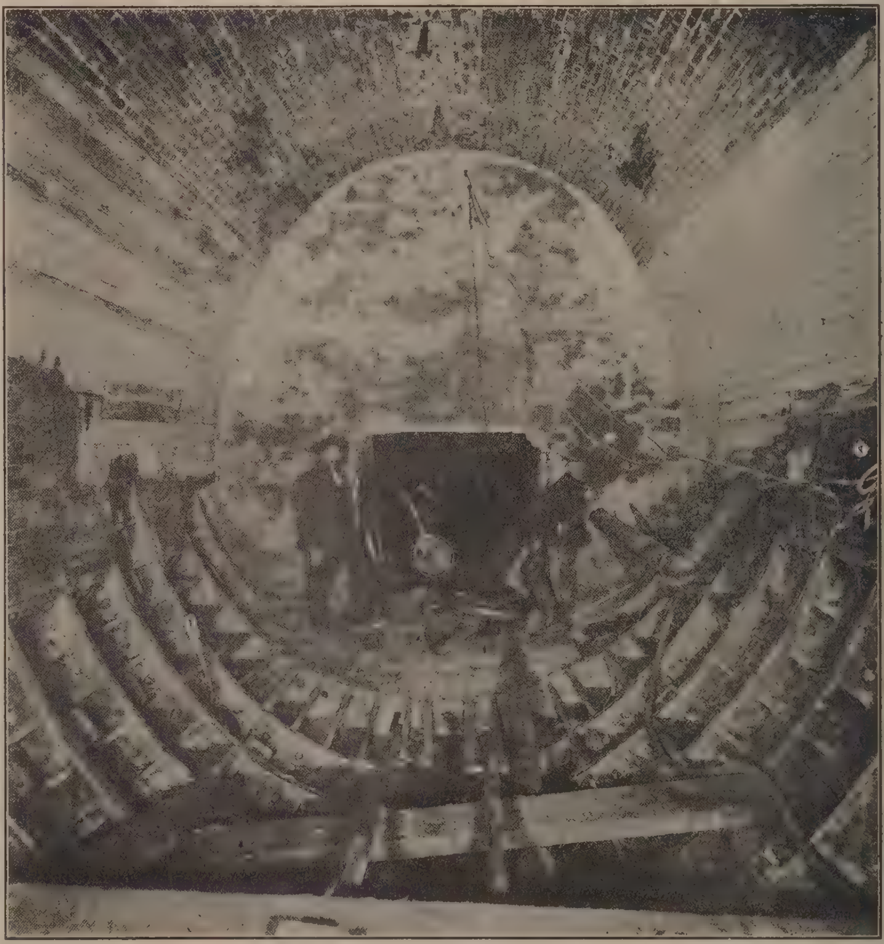
All of the work has been done in soft, wet sand or quicksand and has substantially consisted of removing some of the original arch or invert segments and replacing them with concrete or cast-iron construction, changing the cross-section of the tunnel from a circle to an egg shape. Only a small part of the work was done under atmospheric pressure but for nearly all of it pneumatic pressure was necessary, which of course added to the delay and expense involved. The depression of the invert consisted simply of removing the old segments and rebuilding the lining to the required new dimensions and was done piecemeal with little difficulty.

Where it was necessary to raise the roof, it was at first intended merely to cut through the old lining at about the springing line and replace the upper portion of it with new cast-iron segments providing for an elongated vertical axis and giving the required additional headroom. This did not involve any change of the invert in these parts of the tunnel, and operations were commenced as described in The Engineering Record of March 2, 1905, by the construction of interior timbering which afforded a jacking platform over a clear roadway in the lower part of the tunnel. Special powerful hydraulic jacks were inserted between horizontal distributing and reaction beams on the falsework and fillers fitted to the arch segments. After unbolting and disconnecting the segments on longitudinal horizontal lines, they were jacked 2 or 3 ft. vertically upward into the sand above the tunnel roof, the sand being partly removed to facilitate their displacement by "bleeding" through holes cut for that purpose in the segment webs.

The jacks were removed and the segments temporarily supported by radial shores seated on transverse timber arches inside the tunnel and affording clearance for passage and operations there. On each side of the roof segments thus elevated, lines of thin vertical steel sheeting were driven to exclude the sand and retain the surface exposed between the separated portions of the lining. As the ground water line approached nearly to the lower edge of the sheeting and as that point was considerably above the bottom of the new tunnel lining, the question of removing the remaining segments on the sides of the tunnel and retaining the sand there while the new structure was built, became a very serious one.

It was at first proposed to drive poling boards nearly vertical on both sides of the excavation and as far as practicable from the tunnel axis, so as to enclose the new work, and then endeavor to drain the space between them and the tunnel lining by pumping so as to make it possible to remove the reamining sections of the old segments and construct the new work under atmospheric pressure, being prepared, however, to furnish pneumatic pressure if necessary.

Eventually, this plan was somewhat modified and the work was finally executed, as indicated in the accompanying cross-section, by jacking out the segments on both sides of the tunnel in exactly the same manner as the roof segments had been jacked out; before this was done, however, poling boards inclined somewhat from the horizontal were driven under the lower edges of the roof segments to support the earth there and the vertical sheeting was removed. The segments were then jacked out until their upper ends were nearly in contact with the lower ends of the poling boards, where they were maintained in position by radial shores wedged against the segments and reacting against the arch timbering or bracing in the tunnels. The surface of the earth exposed at the lower ends of the side segments was nearly horizontal, so that no difficulty was experienced in making it stable. During this operation the ground water level was lowered by drawing the water into the lower portion of the tube through several well points, so that it was not found necessary to provide a pneumatic pressure to exclude the water.



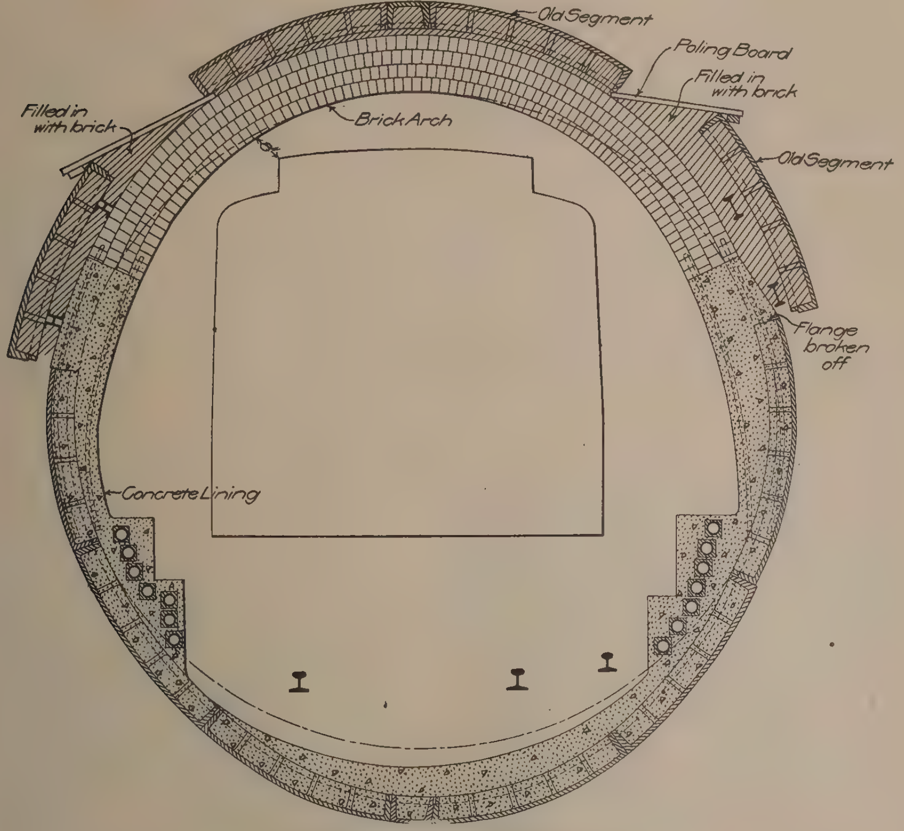
View of Portion of Rectified Tunnel.

A new lining about up to the haunches was then built with concrete, reinforced by three curved 1-in. square bars for every 22-in. ring. This concrete enclosed the upper segments of the old lining and extended about 1½ ft. above them or 4 ft. above the springing line, where it was finished with a radial surface acting as a skewback to receive the 4-ring brick arch roof, which was built on it in preference to continuing the construction with concrete, because the brickwork could be more easily handled in the tunnel and required less time for setting after it was laid, thus considrably expediting the work. The space between the adjacent ends of the displaced segments and those which remained undisturbed in the lower part of the lining was carefully filled with concrete, sealing it against the earth and water pressure, and the remainder of the space between the displaced old segments and the new lining was carefully backfilled with solid brickwork. Care was taken to have the upper ends of the reinforcement rods project about 6 in. beyond the surface of the concrete lining to bond the latter thoroughly with the brick roof arch. The work progressed rapidly and steadily and when completed presented a very neat and satisfactory appearance.

The reconstruction of about 210 lin. ft. of roof arch and 2,676 ft. of invert in both tubes was commenced in April, 1906, and was completed in June, 1907, with an average daily force of about sixteen men for each tube at a fraction of the outlay which it was conservatively estimated would be required for doing the same work by means of a shield built around the old tunnel. The latter method was considered to involve great difficulties in the construction and operation of the shield and serious doubts were entertained as to its practicability. Its control was believed to be a difficult and delicate matter, subject to the same difficulties encountered in the original construction which would, it was expected, be considerably augmented under the new conditions. That the work has been carried on so rapidly and successfully and at such a small comparative cost demonstrate a high degree of skill and ability in the engineers and contractors and must be a source of great satisfaction to all concerned. The work was designed and executed under the approval of the Rapid Transit Railway Commissioners, Mr. Geo. S. Rice, chief engineer, and Mr. Frederick Noble, division engineer. The general contractor was the Rapid Transit Subway Construction Co., Mr. Geo. H. Pegram, chief engineer, the details being designed and executed by Cranford & McNamee, Mr. J. C. Meem, chief engineer, and Mr. W. I. Aims, consulting engineer.

## Cold Twisted Steel Rods for Concrete Reinforcement.

Although a great deal has been written concerning reinforced concrete comparatively little has been published regarding the steel used as reinforcement. The subject was brought up at the recent meeting of the American Society for Testing Materials by Mr. Jesse J. Shuman, chief inspector of the testing department of the Jones & Laughlin Steel Co., in a paper that called forth considerable discussion in which diametrically opposite opinions were expressed by reinforced concrete specialists. Mr. Shuman's paper read as follows:



One Method of Rectifying Battery Tunnel.

View of Jacking Platform, Battery Tunnel.

When a bar is twisted by a machine of the usual type it does not change in length; in fact one end is inserted loosely into the revolving die and there is no tendency to pull out. Hence the central fiber alone is unchanged in length and strength, and the great increase in the strength of the bar is an average of values that are widely different. Moreover, the size of the square has a direct bearing on this average; a point that is commonly neglected in specifications.

If square bars of any size be twisted until they have made one complete turn in 9 times the dimension of a side (pitch = 9), the metal on the corners is stretched about 11.5 per cent. as determined by formulas for helices. The areas of squares, however, vary with the squares of their sides, so that in a small bar the average stretch is greater than in a large bar, and the increase in strength is correspondingly greater. This is amply illustrated by laboratory results in any series of tests in which the size varies, and it should be recognized as a normal manifestation.

The moment the twisting machine has created a permanent set in the fiber, the steel has begun to increase in strength, in the same manner as higher yield-point and ultimate strength are set up in a bar when it is slightly stretched in a testing machine. As the twisting proceeds the yield-point ascends more rapidly than the ultimate strength. There is a point, however, at which the maximum strength of the bar is reached, and beyond which it is reduced somewhat before the bar twists apart.

The interesting behavior of half-inch squares of three widely different grades is shown in Table 1. It would clearly be a mistake to specify a number of turns approaching the maximum strength of the steel, for the internal strains in such a bar are already nearly enough to destroy it; yet it is not uncommon for engineers to do this very thing. In Mr. Shuman's opinion the number of turns should be about half the number at which the steel is at its maximum strength, and in the ordinary soft Bessemer product this means one complete twist in 8 to 10 times the size of the bar; in other words ,the pitch of the twist should be 8 to 10 for Bessemer steel of about 60,000 lb. tensile strength. Basic open-hearth squares of similar grade should have a pitch of 5 to 7 in order to have their best properties developed. If carbons higher than ordinary structural grades are insisted upon, a proportionate concession must be made in the number of twists.

Excellent results have been obtained with both Bessemer and open-hearth steels of a wide range of carbons. It seems reasonable, however, that the grades that have been found to be best adapted to structural work would also be most reliable for reinforced concrete. Bessemer steels containing carbons up to 0.30 or 0.40 per cent. can be twisted successfully, and are very high in tensile properties, but they have the same brittlenes that constitutes the strongest argument against the various hot-rolled and hot-twisted concrete bars. The latter must be high in carbon in order to yield an elastic limit that even approaches that of the soft steel cold-twisted square rods. Surely the lowest yield-point in Table 2, in which are shown results on soft Bessemer bars, is high enough to suit the most exacting requirements.

On low-phosphorous steel the effect of twisting is not as marked as on Bessemer steel, the behavior in this respect being quite similar to that of the same steel when cold-rolled or cold-drawn. The lower results are readily raised, however, by carrying the twisting process further. Table 3 shows what can be expected of basic open-hearth bars of 55,000 to 65,000 lb. tensile strength twisted an appropriate number of turns.

Manifestly it would be a poor plan to use open-hearth steel softer than the tests shown in this table, but it would be both safe and advantageous to use steel up to about 0.35 per cent. carbon, with phosphorus under 0.04 per cent.

Inasmuch as the function of a reinforcing bar is performed inside the elastic limit, the elastic limit is the feature of highest importance from the engineer's standpoint. It is here that the cold-twisted square excels all hot-finished sections, in Mr. Shuman's opinion, and must always continue to do so, for its elastic limit of 60, 70, and even 80 thousand pounds permits the use of less steel for the same service than can be guaranteed by its competitors.

In the testing laboratory it is necessary to take unusual pains to observe the yield-point, commonly called elastic limit, for the reason that the beam of the machine does not always drop when the point is reached at which permanent deformation begins. The machine should be run not faster than ⅝ in. per minute, and in the absence of an autographic device a pair of dividers should be held on the specimen until the yield-point is observed.

Specifications for cold-twisted bars should be consistent with the behavior of steel of known quality, and should recognize the empirical laws peculiar to the material. Thus, to summarize and add to points made in this paper, the following suggestions are offered by Mr. Shuman as a broad foundation for specifications.

1. Process. Specify whether open-hearth or Bessemer steel is to be used, or either. Open-hearth steel should contain less than 0.04 per cent. phosphorus for basic and 0.06 per cent. for acid steel.

TABLE 1. EXPERIMENTS WITH ½-IN. TWISTED SQUARES, SHOWING THE EFFECT OF INCREASING NUMBER OF TWISTS.

| | | Yield-point, lbs. per sq. in. | | | Ultimate Strength. Lbs. per sq. in. | | | Elongation in 8 in. Per cent. | | Reduction of area. Per cent. | | Elastic Ratio. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade. | Turns per Foot. | Plain. | Twisted. | Increase Per cent. | Plain. | Twisted. | Increase Per cent. | Plain. | Twisted. | Plain. | Twisted. | Plain. | Twisted. |
| Soft Bess. | 3 | 41,600 | 65,600 | 57.7 | 60,400 | 83,200 | 37.7 | 28.25 | 10.0 | 64.0 | 49.6 | 68.9 | 78.8 |
| " | 4¾ | 39,200 | 72,400 | 84.7 | 60,000 | 89,600 | 49.3 | 28.75 | 5.75 | 63.4 | 31.2 | 65.3 | 80.8 |
| " | 5 | 41,600 | 84,800 | 103.8 | 60,800 | 92,000 | 51.3 | 30.5 | 6.25 | 65.8 | 36.0 | 68.4 | 92.2 |
| " | 5¾ | 40,800 | 84,000 | 105.9 | 60,400 | 90,000 | 49.0 | 30.0 | 7.5 | 64.6 | 40.0 | 67.6 | 93.3 |
| " | 5⅞ | 40,000 | 80,800 | 102.0 | 60,800 | 88,800 | 46.0 | 27.5 | 3.75 | 60.9 | 25.2 | 65.8 | 91.0 |
| Bess. .25 | 3 | 48,800 | 83,600 | 71.3 | 74,000 | 96,000 | 29.7 | 25.0 | 8.0 | 53.8 | 48.9 | 65.9 | 87.1 |
| Carb. | 4½ | 51,200 | 83,200 | 62.5 | 75,200 | 99,200 | 31.9 | 25.0 | 4.5 | 51.0 | 46.7 | 68.1 | 83.9 |
| " | 4⅞ | 52,800 | 88,800 | 68.2 | 75,200 | 104,000 | 38.3 | 24.0 | 4.0 | 54.4 | 44.5 | 70.2 | 85.4 |
| " | 5 | 51,200 | 84,200 | 64.4 | 75,600 | 102,000 | 34.9 | 22.5 | 5.75 | 50.3 | 44.5 | 67.7 | 82.6 |
| " | 5½ | 53,200 | 84,200 | 58.3 | 75,200 | 100,800 | 34.0 | 23.0 | 6.0 | 51.0 | 28.6 | 70.7 | 83.5 |
| Soft O.H. | 3 | 31,200 | 46,000 | 47.4 | 46,400 | 64,000 | 37.9 | 33.0 | 8.0 | 74.0 | 70.8 | 67.2 | 71.9 |
| " | 5 | 31,200 | 60,800 | 94.9 | 47,200 | 68,000 | 44.1 | 32.5 | 5.75 | 68.7 | 59.0 | 66.1 | 89.4 |
| " | 7 | 31,200 | 68,800 | 120.5 | 46,000 | 76,000 | 65.2 | 37.5 | 6.75 | 73.0 | 67.0 | 67.8 | 90.5 |
| " | 9 | 31,200 | 67,200 | 115.4 | 47,200 | 71,200 | 50.8 | 34.0 | 5.0 | 74.5 | 28.6 | 66.1 | 94.4 |

Note: Bars of each grade twisted off when given more turns than here shown. The "elastic ratio" is the ratio between yield-point and ultimate strength.

TABLE 2. TESTS ON PLAIN AND COLD-TWISTED STEEL BARS, SOFT BESSEMER STEEL.

| | | Yield-point. Lbs. per sq. in. | | | Ultimate Strength. Lbs. per sq. in. | | | Elongation in 8 in. Per cent. | | Reduction of area. Per cent. | | Elastic Ratio. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size Inches. | Turns per Foot. | Plain. | Twisted. | Increase. Per cent. | Plain. | Twisted. | Increase. Per cent. | Plain. | Twisted. | Plain. | Twisted. | Plain. | Twisted. |
| ¼x¼ | 4 | 36,800 | 80,000 | 117.4 | 65,600 | 92,800 | 41.5 | 19.5 | 8.0 | 64.0 | 53.8 | 56.1 | 86.2 |
| ¼x¼ | 4 | 38,400 | 78,400 | 104.2 | 68,800 | 91,200 | 32.5 | 17.5 | 7.5 | 64.0 | 56.5 | 55.8 | 86.0 |
| ⅜x⅜ | 3½ | 39,130 | 71,160 | 81.8 | 61,180 | 85,380 | 39.5 | 26.0 | 10.0 | 67.8 | 55.5 | 63.9 | 83.3 |
| ⅜x⅜ | 3½ | 39,830 | 72,560 | 82.2 | 62,330 | 85,380 | 37.3 | 28.0 | 12.0 | 62.4 | 60.8 | 63.9 | 85.0 |
| ½x½ | 3 | 41,600 | 65,600 | 57.7 | 60,400 | 83,200 | 37.7 | 28.25 | 10.0 | 64.0 | 49.6 | 68.9 | 78.8 |
| ½x½ | 3 | 38,600 | 66,000 | 71.0 | 63,100 | 91,200 | 44.5 | 27.75 | 10.0 | 61.7 | 48.1 | 61.2 | 72.4 |
| ⅝x⅝ | 2¼ | 40,020 | 73,860 | 84.5 | 63,100 | 85,560 | 35.6 | 26.0 | 9.5 | 63.8 | 55.6 | 63.4 | 86.3 |
| ⅝x⅝ | 2¼ | 40,940 | 74,180 | 81.2 | 64,640 | 84,960 | 31.5 | 28.0 | 11.0 | 61.2 | 56.7 | 63.3 | 87.3 |
| ¾x¾ | 1½ | 40,340 | 74,680 | 85.1 | 60,450 | 80,860 | 33.8 | 30.0 | 13.5 | 64.0 | 55.5 | 66.7 | 92.4 |
| ¾x¾ | 1½ | 39,120 | 72,720 | 85.9 | 60,080 | 81,060 | 34.9 | 31.0 | 14.0 | 62.4 | 58.1 | 65.1 | 89.6 |
| ⅞x⅞ | 1¼ | 39,380 | 71,340 | 81.2 | 59,460 | 77,960 | 31.1 | 34.0 | 13.75 | 59.2 | 58.5 | 66.2 | 91.5 |
| ⅞x⅞ | 1¼ | 39,640 | 68,700 | 73.3 | 59,200 | 75,980 | 28.3 | 34.0 | 10.0 | 61.1 | 56.3 | 67.0 | 90.4 |
| 1x1 | 1 | 36,000 | 66,000 | 83.3 | 61,000 | 73,900 | 24.4 | 32.0 | 6.5 | 59.6 | 43.0 | 59.0 | 89.3 |
| 1x1 | 1 | 37,400 | 67,500 | 80.5 | 61,000 | 74,000 | 21.3 | 33.0 | 9.0 | 56.7 | 53.1 | 61.3 | 91.2 |
| 1⅛x1⅛ | ⅞ | 37,550 | 61,640 | 64.1 | 58,820 | 70,680 | 20.2 | 30.0 | 12.5 | 60.1 | 49.3 | 63.8 | 87.2 |
| 1⅛x1⅛ | ⅞ | 38,330 | 63,100 | 64.6 | 58,820 | 70,580 | 20.0 | 31.0 | 12.5 | 56.6 | 50.6 | 65.0 | 89.4 |
| 1¼x1¼ | ¾ | 39,530 | 61,100 | 54.5 | 61,420 | 78,950 | 28.5 | 30.0 | 12.0 | 47.5 | 36.0 | 64.3 | 77.4 |
| 1¼x1¼ | ¾ | 38,251 | 62,510 | 63.4 | 61,300 | 79,270 | 29.3 | 30.0 | 6.0 | 45.2 | 31.5 | 62.3 | 78.8 |

TABLE 3. TESTS ON PLAIN AND COLD-TWISTED STEEL BARS, OPEN-HEARTH OF 55-65,000 LBS. TENSILE STRENGTH.

| | | Yield-point. Lbs. per sq. in. | | | Ultimate Strength. Lbs. per sq. in. | | | Elongation in 8 in. Per cent. | | Reduction of area. Per cent. | | Elastic Ratio. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size Inches. | Turns per Foot. | Plain. | Twisted. | Increase. Per cent. | Plain. | Twisted. | Increase. Per cent. | Plain. | Twisted. | Plain. | Twisted. | Plain. | Twisted. |
| ½x½ | 5 | 38,000 | 58,000 | 52.6 | 61,200 | 92,000 | 50.3 | 27.25 | 5.25 | 64.0 | 11.6 | 62.1 | 63.0 |
| ½x½ | 5 | 37,600 | 60,000 | 59.6 | 60,400 | 91,200 | 51.0 | 28.75 | 5.25 | 65.2 | 31.5 | 62.2 | 65.8 |
| ⅝x⅝ | 3½ | 34,130 | 60,000 | 75.8 | 58,660 | 75,450 | 28.6 | 27.5 | 6.25 | 62.5 | 55.2 | 58.2 | 79.5 |
| ⅝x⅝ | 3½ | 34,880 | 58,480 | 67.7 | 58,220 | 76,060 | 30.6 | 31.25 | 8.0 | 61.1 | 53.7 | 59.9 | 76.9 |
| ¾x¾ | 2½ | 31,170 | 52,800 | 69.4 | 57,020 | 69,670 | 22.2 | 31.0 | 7.5 | 61.2 | 46.5 | 54.7 | 75.8 |
| ¾x¾ | 2½ | 34,370 | 55,770 | 62.3 | 57,050 | 69,300 | 21.5 | 28.75 | 7.5 | 59.7 | 44.8 | 60.3 | 80.5 |
| ⅞x⅞ | 2 | 35,660 | 65,960 | 85.0 | 60,740 | 78,110 | 28.6 | 30.0 | 6.5 | 60.5 | 27.6 | 58.7 | 84.4 |
| ⅞x⅞ | 2 | 35,000 | 60,870 | 73.9 | 59,430 | 71,580 | 20.4 | 29.0 | 8.25 | 50.3 | 45.7 | 58.9 | 85.0 |
| 1x1 | 1¾ | 33,120 | 57,920 | 74.9 | 57,430 | 67,480 | 17.5 | 31.0 | 9.0 | 52.5 | 43.1 | 57.7 | 85.8 |
| 1x1 | 1¾ | 33,360 | 54,350 | 62.9 | 59,060 | 72,300 | 22.4 | 30.75 | 6.0 | 54.0 | 26.8 | 56.5 | 75.2 |
| 1⅛x1⅛ | 1½ | 38,560 | 66,140 | 71.5 | 68,760 | 82,560 | 21.5 | 32.5 | 7.75 | 49.3 | 14.8 | 56.0 | 80.1 |
| 1⅛x1⅛ | 1½ | 32,350 | 57,290 | 77.1 | 56,150 | 72,570 | 29.2 | 32.25 | 5.25 | 60.7 | 14.6 | 57.6 | 78.9 |
| 1¼x1¼ | 1½ | 33,740 | 62,230 | 84.4 | 55,550 | 68,890 | 24.0 | 30.0 | 7.75 | 46.7 | 30.7 | 60.7 | 90.3 |
| 1¼x1¼ | 1½ | 32,950 | 57,140 | 73.4 | 55,810 | 73,340 | 31.4 | 32.0 | 6.25 | 52.0 | 24.6 | 59.0 | 77.9 |

2. Carbon. This should usually be left to the discretion of the manufacturer, who insists that when carbon limits are named the tensile requirements should be left open.

3. Elastic Limit. For squares ½ in. and smaller, this should be at least 65,000 lb.; for squares ⅝ in. to 1 in. at least 60,000 lb., and for squares 1⅛ in. and larger at least 55,000 lb. Manufacturers can generally guarantee minima values somewhat higher than these, but the above would be a reasonable specification.

4. Ultimate Strength. To be recorded.

5. Elongation. At least 5 per cent. in 8 inches, or 12 per cent. in 2 inches.

6. Reduction of Area. To be recorded.

7. Bend. Bars to bend cold around a pin twice their size without distress.

8. Number of Turns. For Bessemer steel, one complete turn in 8 to 10 times the size of the square; for open-hearth steel, in 5 to 7 times the size.

9. Number of Test Pieces. One tension test specimen and one for bending test for each melt used in each size.

10. Inspection. All tests governing the acceptance of material to be made at manufacturer's works. Inspector to have access to the bars prior to shipment, but the manufacturer is not relieved thereby from responsibility for unsatisfactory material. In this connection it may be stated that each bar is thoroughly cleaned by the twisting process, and that each piece is in a large measure tested at the same time, as no imperfect bar will stand the cold-twisting process.

In the discussion of the paper, some of those taking part urged that no distinction should be allowed between specifications for structural steel and those for reinforcement steel. Mr. H. H. Quimby stated that all the steel for reinforced concrete work done under the direction of the Bureau of Surveys of Philadelphia was purchased under the same requirements as governed the steel for bridges and buildings. He was strongly of the opinion, however, that it was not advisable to specify properties of steel bars both straight and twisted, for it was enough to test them in one or the other form. Other engineers stated that there was every reason for departing from the requirements for structural steel in purchasing reinforcing steel. The properties required in structural steel are largely necessary on account of the hard treatment received by the steel during its fabrication into the members used in bridges and buildings. Reinforcement steel is not subject to any such severe treatment and on that account, it is claimed, the specifications governing it need not be the same as for structural steel. Mr. T. L. Condon, who was among those who expressed such opinions, stated that for many years he was an advocate of strich requirements for structural steel. When he first employed reinforced concrete he held that the same grade of metal should be employed in that work. After a longer experience in the design and execution of reinforced concrete he became convinced that the treatment of steel for reinforcement and the work required of it varied so widely from steel structural work that the differences should be recognized in specifications.

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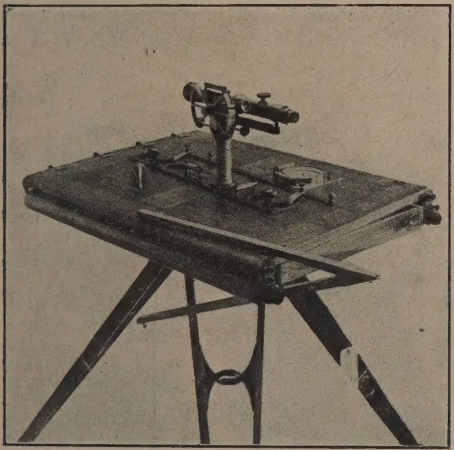
SUBMERGED ROCK BREAKING with a Lobnitz chiseling machine is now in progress at the harbor works of Blyth. About 150,000 cu. yd. of rock were taken out by drilling and blasting before two of these machines and two 700-ton hopper dredges were put in service, and on this account a comparison of the cost of the two methods of working is possible. At the recent engineering conference of the Institution of Civil Engineers Mr. J. W. Sandeman stated that each chiseler consists of a steel barge carrying shearlegs from which is suspended a steel ram weighing 15 tons. It is about 45 ft. long and 17 to 18 in. in diameter, and its conical point can be renewed. The latter is tempered so as to have a hard center with a soft exterior, which enables a sharp point to be preserved. The ram falls from a height of 8 ft. and an average of 8 or 9 blows is sufficient to penetrate the sandstone rock, which is of variable character, about 3 ft., sufficient to permit it being dredged to a depth of 2½ ft. One machine working day and night and allowing for all stoppages averages about 900 cu yd. of rock broken per week at a cost of 8.8d. per cubic yard. Adding various contingencies and expenses for repairs not included in the figure mentioned, the total cost is about 14.5d. Drilling and blasting the rock cost about 3s. per cubic yard and left it in a somewhat less favorable shape for removal than the rock broken by a chiseling machine. The blasted rock cost 3s. 2.2d. per cubic yard to dredge, while the broken rock left by a Lobnitz machine cost but 2s. 9.1d. to dredge. Summarizing all the figures it was found that the rock breaker made a saving of 2s, 2.6d per cubic yard.

## The Topographical Survey of Staten Island.

The preparation of a topographical map of each borough of New York is required by the city charter. The work of preparing such a map of the Borough of Richmond was begun in August, 1902, five men being put in the field at that time. Since then the working force has been steadily increased until there are now about 120 men employed. This Borough, otherwise known as Staten Island, is triangular in general form, its area being 57¼ square miles. It has a maximum width and length of 7 and 14 miles, respectively. The island is very hilly, the highest points being about 400 ft. above sea level. Trees and brush cover a great part of the surface and numerous small streams divide it into a large number of small watersheds. Though some portions are thickly settled, the total population is only about 77,000, or 1,350 per square mile. The unusual conditions existing in the Borough have resulted in the adoption of methods which differ from those ordinarily employed for topographical surveys.



Improved Plane Table.

Portable Tower.

The primary purpose of the topographical survey is to secure data for planning a street system, but the information is also valuable in planning drainage and sewerage systems and most other public improvements. As in the other New York boroughs, the work of primary triangulation is to be done by the United States Coast and Geodetic Survey. As a preliminary measure a reconnaissance of the island was made by the topographical division of the engineer corps of the Borough and 43 stations have been selected and a map prepared showing their intervisibility. The stations include sixteen towers, four lighthouses, twelve public buildings and eleven other buildings, mostly residences. The base line is about 1¾ miles long.

As it was necessary to carry on the survey before points of control could be determined by tringulation, it was important to measure the primary traverses very carefully. It was soon found that the common 50-ft. spring-balance chain used horizontally was not satisfactory, because of the many steep grades and the extreme care necessary to secure accurate results. A system of measurement along the slope was therefore devised which depends on the plumb bob only at the ends of a measured line. A standardized 100-ft. steel tape is used, a 16-lb. pull being applied with a spring balance and the temperature taken as usual. Solid steel tripods, with a spread of about 2½ ft. and a height of about 2 ft., are used, on which to mark successive tape lengths, the elevation of the tripod heads being obtained with a wye level and proper corrections made for inclination and temperature. The tape is suspended between the end marks without intermediate support. Duplicate measurements are made, which must agree within 0.01 ft. × (0.00003 × the distance in feet), or the line is remeasured, which is rarely necessary. With a party of six a line can be run in this manner faster than with the 50-ft. spring-balance chain and the cost is about the same.

The traverses, which are limited to about 10,000 ft. in perimeter, are made as nearly square as practicable and usually close within about 1 in 30,000. The ten or more traverses in a section are adjusted together, commencing with the one having the largest error of closure, so that the maximum error in a section is made as small as possible. The sections are adjusted systematically one to another so that all errors are limited in amount and properly distributed. A single system of co-ordinates is thus obtained. The traverse work is built up in a compact body extending outward from the first adjusted section and is kept in advance of the work of filling in the detailed topography. Marble monuments, 4 in. square and 30 to 40 in. long, are generally used to mark important traverse points.

Level circuits for establishing bench marks are run with wye levels, forward and backward in closed circuits of about the same size as the primary traverses. A number of level circuits are adjusted together in the same manner as the traverse circuits. Bench marks are selected in pairs so that the elevation of any bench mark may be checked by another nearby. The bench leveling is kept in advance of the work of detailed topography and both field work and adjustments are carried forward as the survey proceeds.

In thickly settled districts the work of filling in detailed topography is done with the transit and the contours are traced by the wye level and located with the tape. Outside the thickly built-up districts the location of all instrument stations, monuments, property lines, buildings, and the like, is determined by the transit in advance of the contour work. The contours, which are traced with a wye level, and the other topographical details are then located by the stadia, using either the plane table or transit.

When the survey was begun, the transit and stadia method was generally used, the computations and mapping being done in the office, and the maps then taken into the field and checked. So many of the stadia traverses had to be rerun to close within the assigned limit of error, that it was soon found more economical to tape and level over all instrument stations and depend on the stadia method only for determining points about a station fixed by the transit, tape and wye level. A fault of this method is that too much depends on the judgment of the rodman in selecting points and when errors of reading occur, it is difficult to detect them.

The unsatisfactory results secured by the transit and stadia method and the fact that draftsmen could not be obtained to plot the survey promptly, led to the design of a special plane table shown in an accompanying illustration. This instrument is designed to accommodate the 27 x 40-in. Whatman's "Double Elephant" sheets on which the survey is plotted. Under each of the longer edges of the 22 x 28-in. board is a 2-in. roller with a ratchet with which the sheet can be drawn tight, a special clamp being used to hold the entire edge of the sheet to the rollers. The alidade is equipped with a 20-in. parallel ruler, which makes it unnecessary to give attention to the position of the ruler edge in taking a shot. The under side of the ruler and base plate is covered with white celluloid, which does not soil the paper like a brass surface. The telescope is of the inverting type, as are all those used on the work. It can be turned completely through a vertical circle and the vertical scale is equipped with a floating vernier. The sector-shaped swinging drawer turns on a pivot and can be opened and closed with little risk of disturbing the instrument.

The contours are traced with a wye level and plotted at once on the plane table sheet, the distances being determined by the stadia. Rods 12 to 18 ft. long are used and the telescope is kept in a practically level position. The contours are traced across all streets and streams and all features of any importance are shown. The map is thus available for use as soon as taken off the table. The traced contours represent the topography much more accurately than those drawn by interpolation and are much superior for grade studies. The instrumentman can at any time compare the map and the ground and errors or omissions are almost impossible. While tracing contours is somewhat more expensive than taking isolated elevations by the stadia, when the cost of computations and the inaccuracy of interpolation are considered the balance is largely in favor of the tracing method. The location of contours, on ground of average slope, requires a more accurate determination of the elevation of the selected points than of their horizontal position. The tracing method thus gives increased precision where it is most needed, while the reverse may be said of the transit and stadia method.

In open country, where the maximum slopes do not in general exceed 5 per cent., a party consisting of a plane table man, levelman and two rodmen can cover about 8 acres per day. When the country is rougher or wooded the area covered is less, about 5 acres being the minimum. In wooded country 2,600 ft. of contour line per day is considered good progress, and in open country a mile per day is about the average.

The field parties work every clear day during the year. During the winter they are kept in the wooded districts as much as possible and in the summer when the foliage is heavy they work in the open. To facilitate the work where brush is thick, a portable tower has been devised on which both plane table and level may be set up. With the tower a very long rod is used and the contours can thus be traced without clearing off the brush. The platform is 8 ft. above the ground and is 9x6 ft. It is made in two sections, each 3x9 ft., so that it may be more readily carried about. The posts are 4x4 in., the braces 2x1 in., the platform stringers 2x4 in., and the floor 1-in. matched flooring. Bolts with thumb nuts are used to fasten the various parts together.

In connection with the transit and stadia work two portable field offices have been used in which the plotting can be comfortably done in all weathers, close to the field party. These offices, which were described and illustrated in The Engineering Record of Dec. 19, 1903, are substantially built of wood, with glass windows and awnings and are mounted on a spring wagon gear. The climate of Staten Island, while it is seldom too severe for field work, is so changeable that such shelters are very valuable.

The survey is plotted 27x40-in. sheets to a scale of 50 ft. to the inch. The contours are shown at intervals of 2 ft. below El. 50 and at 5-ft. intervals above. All important topographical features are shown and all transit lines and measurements to locate buildings, monuments, and property lines are given. This scale, while somewhat larger than that usually employed on such work, has proved very satisfactory for mapping thickly built-up districts. The plotting can be done with less strain on the eyes than with a smaller scale, and any errors due to inaccuracy or shrinkage of paper are diminished in magnitude. The cost of the survey depends mainly on the accuracy and amount of detail obtained, and when these remain the same the cost is not increased materially by the use of the larger scale. The least accurate part of the survey is the location of contours and topographical details by stadia measurements. With the telescopes used, which were specially designed for stadia determinations, these measurements are correct to within about 1 ft. in 400, and as the longest sights are not over 600 ft. the maximum error of location of a contour does not exceed 1½ ft. If the map is to represent the contours as accurately as the survey warrants, a scale large enough to show errors of this magnitude is required. These maps have proved very satisfactory in preparing detailed plans for streets, drains and sewers.

Though the field sheets are well adapted for the study of details they are on too large a scale for many purposes, particularly for the study of a general street system involving the consideration of a large area at one time. It was decided that for such purposes a scale of 150 ft. to an inch would be most satisfactory, since a large area could thus be shown on a sheet of practicable size, which is necessary in comprehensive planning, and at the same time the topography could be represented with proper accuracy. At first the usual method of reduction with the precision pantagraph was used, but this proved so inaccurate and expensive, particularly when much detail was required, that resort was had to photography. Photographic prints of topographical sheets can be copied by means of a stylus and carbon paper if only one copy is needed, but when a number of copies of each large-scale map are required they can be obtained best by photolithography, by which all the details of the original field sheets are reproduced accurately and economically.

The lithographic sheets are made the same size as the field sheets and nine of the latter are required to make one of the former. The field sheets have to be carefully matched in order that the junction of the separate sheets will not be apparent, and lines and letters have to be made of proper strength. Negatives, 8⅓x12⅔ in., are first taken of each field sheet. Prints from these negatives are then made on photolithographic transfer paper and these prints are then carefully trimmed, mounted, matched and pasted together upon a large sheet of paper. This built-up transfer is then put down in the usual manner on the lithographic stone, from which as many copies are printed as are desired. The maps of the Borough of Richmond have been printed in editions of 400. On account of the number of processes involved and wetting and stretching of the paper, care is required to preserve the accuracy of the scale, but the error need not exceed 1 in 500. These lithographs fully meet the requirements for maps on which to project street layouts and similar studies, as they contain all the data on the field sheets.

About 764 27x40-in. topographical sheets will be required to map the entire borough. Of these, 245, covering much of the most thickly settled portions, are either completed or in progress. Since the survey was begun the work has been done under the direction of Mr. George W. Tuttle, engineer in charge, and Mr. Louis L. Tribus, consulting engineer and Commissioner of Public Works. The improved plane table was designed by Mr. Edward M. Law, assistant engineer. Nine of these instruments are now in use, all of which were supplied by the Keuffel & Esser Co., New York.

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Maintenance-of-Way Work has a direct influence on the cost of repairs to electric railway equipment, according to Mr. W. R. W. Griffin, of the Rochester & Eastern Rapid Ry. In 1905, the second year of operation of that road, $11.20 per thousand car-miles was spent for maintenance of way, $14.52 for maintenance of cars and $5.20 for maintenance of electrical equipment. In 1906, $15 per thousand car-miles was spent on maintenance of way, $10.77 for maintenance of cars and $5.42 for maintenance of electrical equipment. This saving of $1.01 per thousand car-miles in the total maintenance charge (after eliminating expenses for painting and damaged car bodies) is attributed to the better condition of the track during 1906.

## The White-Souther Endurance-Test Specimen.

A paper read before the convention of the American Society for Testing Materials by Henry Souther.

For certain classes of work, I believe that an endurance test is the best measure of the value of any given material for any given purpose.

Back in the days when the bicycle was most popular this fact was forced upon me, and I rigged up in my laboratory many forms of endurance test. I not only used test specimens as such, but I tested by endurance methods many structures, as, for example, assembled wheels, assembled bicycle frames and forks, and bicycle cranks. All of these tests answered the problems for which they were contrived with the greatest finality. I did not hesitate to make recommendations based upon the results obtained; they were conclusive.

The one possible exception to this statement refers to the endurance-testing machine for test specimens. I took for my model the kind of machine used at the Watertown Arsenal, with which I was familiar. Much experience has been gained with that machine, and a great many results were available in the government records; so I hoped it would answer every purpose. The results obtained with it were not as consistent as they should have been, although, as I have already stated, much good work was done and definite results obtained, upon which to base recommendations.

Mechanical difficulties developed with it, due to its construction. The construction consisted of what amounts to a lathe bed with head and tail stocks 33 in. apart, and provided with universal joints, so as to permit the bending of the specimen, the load being applied at the middle supported upon some form of bearing, either roller or plain journal.

The specimen was objectionable, it being very difficult and expensive to make so long a one and get it exactly right. Owing to its length, it vibrated to a greater or less degree; the vibration, differing in different tests, put upon the specimen different and immeasurable stresses Also, at the point of application of the load, more or less heat developed and to a greater or less extent must have influenced the test, because the heating came at the point of greatest bending moment. High speeds with this form of specimen were out of the question, because of the heating, and something like five or six hundred revolutions per minute seemed to be the upper limit. All this criticism is not with the idea of detracting from the value of the work

Table 1. Results of Endurance Tests of Steels with Fiber Stress of 53,600 lb.

| C. | P. | Mn. | S. | Si. | Ni. | Cr. | E. L. sq. in., lbs. | M. S. sq. in., lbs. | Red. of Area, Per cent. | Elong. in 2 in., Per cent. | Endurance End No. 1. | End No. 2. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .40 | .037 | .63 | .033 | .... | .... | .... | 59,800 | 81,200 | 51.8 | 30.5 | 19,300 | Jumped and bent | Natural condition. |
| .47 | .049 | 1.14 | .043 | .... | .... | .... | 75,900 | 113,400 | 56.3 | 28.5 | 156,600 | Taken out | do. |
| .25 | .008 | .59 | .007 | .... | 3.49 | .... | 55,400 | 79,800 | 61.8 | 29.5 | 33,500 | 75,400 | do. |
| .30 | .059 | .62 | .012 | .... | 3.63 | .... | 61,300 | 90,800 | 46.8 | 23.5 | 165,000 | 435,000 | do. |
| .35 | .013 | 1.82 | Trace | .609 | 2.02 | .... | ....... | 176,800 | 35.0 | 11.5 | 108,301,900 | 108,301,900 | Annealed at 1150° F.<br>Did not break. |
| .287 | .035 | .62 | .027 | .... | .... | .... | 157,200 | 178,200 | 32.9 | 12.5 | 615,100 | 636,600 | Natural condition. |
| .267 | .043 | .41 | .063 | .... | .722 | .... | 111,400 | 140,400 | 57.5 | 20.0 | 100,000,000 | 100,000,000 | do. Did not break. |
| .385 | .017 | .40 | .019 | .... | 1.75 | 1.02 | 76,500 | 104,000 | 50.5 | 21.5 | 65,100 | 76,500 | do. |
| .33 | .014 | 1.66 | .002 | .766 | 1.18 | 1.17 | 66,300 | 89,300 | 66.8 | 29.0 | 3,900 | 4,200 | do. Both ends bent. |
| .385 | .017 | .40 | .019 | .... | 1.18 | 1.17 | 84,600 | 109,200 | 57.4 | 18.5 | 609,300 | 1,492,800 | Quenched at 1500° F.<br>Annealed at 1050° F. |
| .894 | .015 | .31 | Trace | .... | .... | .... | 77,500 | 135,700 | 21.8 | 8.0 | 70,500 | 135,700 | Natural. |
| .894 | .015 | .31 | Trace | .... | .... | .... | 70,300 | 131,800 | 18.4 | 6.0 | 56,100 | 17,000,000 | Quenched at 1500° F.<br>Annealed at 1050° F. |
| .656 | .013 | .39 | .029 | .... | .... | .... | 53,800 | 84,200 | 57.4 | 28.0 | 23,000 | 27,500 | As received (Krupp). |
| .656 | .013 | .39 | .029 | .... | .... | .... | 81,700 | 155,300 | 51.0 | 19.0 | 89,700 | 188,700 | Quenched at 1500° F.<br>Annealed at 1050° F. |
| .405 | .035 | 1.05 | .027 | .160 | .... | .... | 95,300 | 113,500 | 58.8 | 21.0 | 168,500 | 416,400 | As received (Krupp). |
| .405 | .035 | 1.05 | .027 | .160 | .... | .... | 129,500 | 143,500 | 52.3 | 16.0 | 147,700 | 205,700 | Quenched at 1500° F.<br>Annealed at 1050° F. |
| .313 | .083 | 1.04 | .039 | .450 | .57 | .92 | 92,900 | 115,[illegible]00 | 55.1 | 22.0 | 1,040,100 | 11,044,000 | As received (Krupp). |
| .313 | .083 | 1.04 | .039 | .450 | .57 | .92 | 143,900 | 157,800 | 44.4 | 15.0 | 4,755,900 | Taken out | Quenched at 1500° F.<br>Annealed at 1050° F. |

Table 2. Endurance Tests of Manganese Bronze.

| Sample. | Cu. | Sn. | Pb. | Fe. | Zn. | Red. of Area. | Elong. in 2 in. | Sample. | E. L. sq. in. | M. S. sq. in. | Load. | Fiber Stress. | Endurance No. 1 End. | No. 2 End. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gov. Stand. Casting Bronze.... | 59.47 | 0.71 | 0.18 | 1.60 | 38.04 | 25.1 | 26.0 | 36830 | 46,200 | 80,600 | 35 | 12,350 | 1,793,000 | 1,793,000 |
| | | | | | | | | | | | 75 | 26,500 | 1,220,100 | 1,904,300, broke |
| Rolled Rod.................... | ..... | 0.71 | .... | .... | ..... | 23.6 | 22.5 | 36831 | 55,200 | 72,500 | 35 | 12,350 | 1,572,100 | 1,572,100 |
| | | | | | | | | | | | 75 | 26,500 | 9,993,500 | 12,153,800 No. 1 broke |
| | | | | | | | | | | | 100 | 35,300 | .......... | 3,710,800 No. 2 broke. |
| Rivet Stock.................... | ..... | 0.71 | .... | .... | ..... | 65.1 | 42.0 | 36832 | 38,500 | 64,100 | 75 | 26,500 | 10,078,700 | 10,078,700 |
| | | | | | | | | | | | 100 | 35,300 | 536,400 | 1,011,800, broke |

done at Watertown, because I believe it has been very valuable, but simply to show my starting point in the evolution of an endurance machine.

With all these facts in mind, Mr. Maunsel White and myself devised a test specimen which seems to do away with all the objections mentioned without introducing others of serious moment.

This specimen, measuring about 13 in. over all, is a comparatively cheap one to prepare; also, as it is large at its center, there is little trouble in the lathe due to bending. It is, therefore, quite easy to make accurate to size and straight. It is a double-ended specimen, which makes it possible to obtain definite results, even though there may be a flaw or other defect in one end. This double-ended specimen also gives check results in case both ends are sound. I feel that the higher of the two results is the proper one to accept, inasmuch as it is the highest measure of the efficiency of the material under test, and no material can endure beyond its capacity.

The specimen is supported at the center portion on large ball bearings, and may be rotated at very high speeds. No heat is produced, at least no great amount of heat, and, even if it were, the center portion being larger than the ends, it would matter little. There is no wear of any kind on the specimen, the loads being applied at the ends, not at the point of greatest bending moment. The critical points of the specimen are, of course, the fillets, coming at the point of greatest bending moment. These must be accurate to shape and perfectly machined; slight flaws or defects at this point are serious.

Table 3. Endurance Tests of Aluminum.

| Mn. | Cu. | Zn. | Al. | Spec. Grav. | M. S. sq. in. | Fiber Stress. | Endurance No. 1. | Endurance No. 2. | |
|---|---|---|---|---|---|---|---|---|---|
| 0.11 | 7.84 | 0.00 | 92.05 | 2.86 | *16,000 | 16,600 | 558,600 | 816,500 | Broke |
| Trace | 0.34 | 16.24 | 83.42 | 2.97 | *25,000 | " | 1,550,400 | 1,618,300 | " |
| ..... | 3.20 | 26.72 | 70.08 | 3.23 | 32,000 | " | 1,613,900 | 477,600 | " |
| ..... | 6.80 | 22.78 | 70.42 | 3.22 | ....... | " | 3,438,400 | 435,500 | " |
| .. .. | 8.20 | 22.44 | 69.36 | 3.24 | 20,000 | " | 12,038,500 | 815,600 | " |
| ..... | 3.00 | 27.00 | 70.00 | 3.30 | *30,000 | " | 5,415,900 | 257,300 | " |
| ..... | .... | 27.00 | ..... | .... | ....... | " | 3,029,900 | 543,000 | " |
| ..... | .... | 27.00 | ..... | .... | ....... | " | 2,513,300 | 707,200 | " |

*Estimated from other specimens.

I append herewith a table of characteristic results obtained without going into exact details. This series of tests was undertaken to get a ground work for suitable comparison. For example, the first specimen may be classed as high grade machine steel. It will be noted that the elastic limit was about 60,000 lb. per square inch, as shown by the tensile test. My idea was to break this quickly, and I therefore loaded it with a fiber stress of 53,600 lb. per square inch and quick results were obtained, as expected. I then went forward with high grade material, one after another, variously treated, the heating being carefully done in an electric furnace in connection with a pyrometer. There are some exceptions to this, in that some of the specimens were tested as received.

The results obtained show the tremendous possibility in the use and adoption of high grade materials. The tests also show that in order that the endurance test may not be too prolonged and therefore not practicable, it must be conducted in such a way as to give quicker results than some of those given. For example, it is practically out of the question for a manufacturer to wait for a machine to run one hundred million revolutions, or probably ten weeks, running night and day at 1,300 r. p. m. Consequently, I have adopted lately an increasing fiber stress; for example, starting the test at 50,000 lb. fiber stress, and, if the specimen endures for ten million revolutions, increase it to 60,000 lb., and after the next ten million increase it to 70,000 lb., and so on until rupture occurs. It is still possible to compare the behavior of various steels and to show the results graphically. The test is, consequently, more useful because more valuable.

A higher number of revolutions than adopted for our tests may be used with this machine, if considered desirable, but I feel that 1,300 r. p. m., more or less, is a practical number. For example, the crank shaft of an automobile rotates at that speed, and there are many rotating parts in the manufacturing industries that are near that speed. Were a very much higher number to be adopted certain unknown elements might be introduced into the test that would render the results questionable, as being a test carried on under abnormal conditions.

For any manufacturer whose product goes into machinery subjected to dynamic loads, such a test ought to be extremely valuable. Further, the heat treatment of steel and the great benefits derived from it are rapidly being appreciated and increasingly used by all manufacturers. Such a test is a measure of the benefit due to heat treatment. Moreover, I have found that certain clients in talking about the increased strength of new alloys and heat treating in general, have said—Oh! yes; of course there is a great increase in strength and apparent toughness and good qualities in general, but how about the capacity of the metals in such a condition to resist shock?" I believe that this test does show the capacity of metals to resist shock, whether of impact nature or alternate stress.

In the table of results given will be found a number of aluminum and bronze specimens which are very instructive.

We are just beginning to get at the results of tests on vanadium steels. The few we have that are trustworthy show a considerable benefit under the endurance test, but I do not like to put them on record, for there are certain features of the treatment unknown to me. We also had the misfortune to have our pyrometer go wrong in connection with the treatment of several specimens, and the results are, therefore, worthless. To generalize, however, it is my impression that vanadium will add to the endurance of any given steel if present in quantities aproximating 0.25 per cent. The increased endurance seems to be at least four to one, but in view of the above lack of knowledge on my part as to all the conditions, I do not wish to commit myself fully.

## A Pile Pointing Machine.

A pile pointing machine has recently been built in England for the use of Messrs. E. Robinson & Sons, contractors for the Rotterdam harbor works. Its purpose is to taper the end of fir piles 20 in. square, leaving them 5 in. in diameter at the point and extending the taper back about 4 ft. Illustrations of the machine in "Engineering" show that the pile is clamped rigidly in a horizontal position, and a conical shaving head, with a knife on its inner surface like the old-fashioned pencil-pointing device, is then pushed against the end of the pile. The cone containing the knife is driven by a belt and the whole cutting head is gradually forced forward by a screw in the same way that the tool-holder of a lathe is traversed. The machine is stated to point a pile in about 15 min., leaving it in a condition ready to receive the iron shoe used at these works.

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The First Railroad in Morocco, Africa, was opened some months ago. It was built by a German company to haul stone from a quarry to tide-water and is only about 1¼ miles long.

## Book Notes.

The Bureau of the Census, of the Department of Commerce and Labor, has issued a bulletin containing some instructive figures of the condition of the electrical industry in 1905. The author, Mr. T. Commerford Martin, has succeeded in investing the dry statistical data of an ordinary census report with deep interest by his explanation of the changes in the electrical art which are the underlying cause of the numerical developments in the classes of apparatus for which figures are given. The report is, in fact, a well-written and authoritative summary of progress in electrical engineering during the five years ending Dec. 31, 1904.

It is pretty well recognized now that in preparing a textbook on certain engineering subjects for class room use it is advisable to abandon some of the conditions which would govern the writing of a treatise for specialists. The requirements of teaching and the knowledge possessed by students when they take up a subject must be considered in determining the sequence of the topics in a school book, and the author's ability as an instructor is often revealed by the departures he makes in a text-book from the order of presentation of topics which would be followed in a treatise. These reflections are suggested by the excellent "Steam-Engine and other Heat Motors" by Prof. W. H. P. Creighton, which is a model text-book. It is highly gratifying to observe that the author has had the courage to compress the subject of thermodynamics into the space it really should occupy in an engineering text-book, and has taken into account the desirability of assuming that, by the time the student is able to take up the steam engine, he has already acquired in other classes and by association with upper classmen enough knowledge to warrant introducing the vital subject of indicator cards before the principles of thermodynamics are discussed. This is one of the many indications in the book of the author's knowledge of the needs of students as well as his thorough acquaintance with his subject. The latter is shown on every page in the concise yet clear manner in which the matter is presented and in the excellent choice of numerical examples, selected so as to make the student grasp all aspects of a topic instead of very limited portions of it, like most exercises in text-books. It is also shown in the presentation of a subject in all its complexity at the outset, and the deduction of the more simple cases from the general case, a procedure that is far better from a teaching point of view than the reverse one. In short, the book is one calculated to make the student think logically, to interest him in his work, and to respect what knowledge he possesses at the outset of his study. The contents of the volume are well indicated by the chapter headings: Review of elementary principles and general view of steam engine plant; Steam engine indicator and its calibration; Curves and the work of expansion; Zeuner and Bilgram valve diagrams and design of plain slide valves; Measuring the effects of heat; Measuring the effects of heat on water and steam; Measurements of heat losses; Entropy; Condensers and air pumps; Small auxiliaries; Multiple-expansio[illegible] engines; Revolution control; Steam variation co[illegible] trol; Steam engine tests; Superheated steam a[illegible] steam turbines; Gas engines and gas produce[illegible] Boiling in a vacuum; Refrigeration; Appe[illegible] of useful tables and physical data. These sub[illegible] are presented with a nice appreciation of [illegible] relative importance and of the distinction b[illegible] what is appropriate for a class in engineer[illegible] one in physics, and the volume as a wh[illegible] particularly important contribution to o[illegible] engineering text-books. (New York, J[illegible] & Sons, $5.00).

## Letters to the Editor.

### Ejector Practice.

Sir:—Regarding the inquiry in your issue of June 15 concerning the use of ejectors for delivering water against pressure, I think it is worth while to notice that in this year's "La Technique Sanitaire" there was a description of a successful arrangement of this kind made by Koerting Bros., of Hanover, Germany. The purpose of this arrangement was to force the water from a low-service reservoir into a pipe system when the latter is operating under the high fire pressure furnished directly by the pumps. The accompanying diagrams indicate the position of the apparatus. In the first diagram, for everyday service, the low pressure is directly from the reservoir, as shown. In the second diagram, showing the conditions during fire service, the high pressure from the fire pumps passes directly to the mains, the low-pressure reservoir being cut off by the valve, as indicated. Water from this reservoir is taken into the pipe line, however, through the ejector, which is thus in use under the conditions mentioned by your correspondent.

Yours truly, Boris N. Simin.

Moscow, Russia.

### Anchoring Bridge Spans.

Sir: May I put a few words in your columns about the anchoring of bridges against a vertical lift. Nearly all standard specifications provide that "all spans shall be anchored against moving sideways or lifting vertically" but how many of our modern bridges are securely held against a vertical pull is problematical. I do not refer to the design but to the setting of the anchor bolts at the time of erection.

Is the hole in the masonry drilled large enough to allow the cement fronting to find its way to the bottom to surround the anchor bolt thoroughly and efficiently and provide for the performance of its full duty? Of what use to drill a hole and stick a bolt 16 in. into the masonry and so small the fronting can penetrate but 4 or 5 in. and even then perhaps does not surround the bolt? Such a bolt may be good for moving sideways, but what about the emergency when the uplift comes?

In the ordinary proceedings for erecting a bridge the anchor bolts are put in last or any old time on the fixed end and the expansion end must be left till the span is swung. On both ends, therefore, the holes are drilled through the bed plate castings and their size is governed by the holes in these castings. When these holes are barely large enough to admit the bolts, which is often the case, we get the same condition down into the masonry.

If the bolts cannot be set before the span is erected, the writer's experience for best results has been as follows: Drill the hole as large as the casting will permit and at least an inch deeper than the bottom of the fixed bolt, unless it be with a split wedge end. Mix the fronting of neat cement or cement and sand to a good flowing consistency and fill the empty hole about one half full. Now let or drive in the bolt to its proper depth and if sufficient grouting has been
oured into the hole it will overflow at the
p.

The hole is now entirely filled, the anchor
is entirely surrounded and, when set, the
er believes, a better and more efficient an-
ge can be secured than by the usual method
ring in the grouting after the bolt is driven.
co-operation of the masonry can then in
cy be depended upon and the bolt can
the duty for which it was designed.

truly yours, H. N. Peck.

Jalisco, Mex.

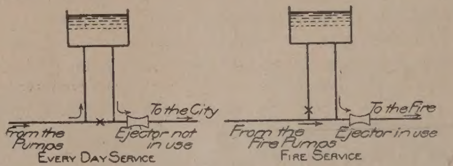
### Chromic Acid as a Rust Inhibitor.

Sir:—I notice in your article on "New views of the cause of the corrision of iron" in yours of July 6th that you state as follows:

"The fact that chromic acid and its salts act as inhibitors of rusting has been known for some time, but no explanation of the curious phenomenon has ever been offered heretofore nor has its application to practice ever been suggested. Dr. Cushman has made a special study of this problem, and although it remains to be seen what practical benefits may develop out of these new ideas, it is most gratifying to be able to state that if any patents are granted covering rust inhibitors they will be taken out in accordance with the practice of the Department of Agriculture, so that they will be free for all American citizens."

From this it is evident that you have not seen the report made by the Committee of Tests of the Master Car and Locomotive Painters' Association, submitted by them at their last annual meeting in 1906 in which they state as follows:

"Steel Plate Exhibit No. 269 represents a small plate of steel exposed to the weather for twenty-eight months, after having been treated with an exploited chromic acid rust-neutralizing process, the powerful black staining chromic acid preparation being knife applied over the entire surface, half of which was then coated with an especially furnished graphite and oil mixed paint.



A French Ejector Application.

"The Committee suggests a critical examination of this exhibit, which, it judges, shows that all up-to-date attempts at chemically oxidizing a steel surface against future corrosion have been attended with failure, such as is indicated by this badly under corroded plate so treated, but you will also please note that the single coat of honest graphite paint is still a protective coating, notwithstanding the hard task of holding its ground against this most powerful acid, said to be soluble only in water, which if true, would fully account for its apparent failure as a corrosive preventative."

Judging from the above and from our own researches, I do not believe that chromic acid can be used with any success as a protection against corrosion in metal surfaces.

Yours truly, Frank P. Cheesman.

### Cable and Hollow Rod Drills for Blast Holes.

Sir:—With reference to a letter from Mr. W. T. Kershner, of Hell Gate, Montana, published in your issue of June 1, 1907 (page 665), describing "a competitive test" of a Keystone cable drill and a Cyclone hollow-rod drill on a blast hole proposition of the Winston Bros. Co. at Hell Gate, we have the following correction to make:

The statement that "the drills were operated by the makers" is at least partly in error, as the Keystone Driller Co. had no representative or employe at the scene of operations either before or during the "test." Mr. R. H. Horrell, who operated the cable drill, is a competent driller but has been in no way connected with the Keystone Driller Co. Mr. Horrell was favorably impressed however, with the work of the cable drill, and we have the following report from him under date of May 16, on this subject:

"On April 8 I arrived at Missoula, Mont., being to report to Winston Bros. Co., to set up and operate the machines that were shipped there along in January, which were a long time on the road, on account of the heavy traffic west of St. Paul.

"Upon arriving there, I found that they had also ordered a Cyclone machine, which arrived a couple of days afterward, being put in competition with the Keystone machine. Only one machine was set up and operated for the time being. We commenced practically at the same time with both machines, the Cyclone people having a practical driller on the ground to operate the machine in drilling blast holes for the cut, which is to be 150 ft. wide and 125 ft. in depth.

"The material is taken out 20 ft. at a time, and hence the holes do not run over about 20 ft. in depth, the rock in most cases being exceedingly hard.

"During the time of being there we operated one machine, and in nineteen days we drilled 1,200 ft., which included the moves from place to place, while the Cyclone in the same length of time drilled 800 ft. In part of the time at this work, the work was in cleaning out holes that were sprung, and on this class of work we were set side by side with the Cyclone machine, starting at the same time. The Keystone succeeded in cleaning out fourteen holes to the Cyclone's six, in one day. This will give you an idea of the work being done by the two machines. The Cyclone people had an A No. 1 practical man on their outfit and it was pushed to the limit.

"In the amount of drilling that was done their rope was entirely worn off in drilling 800 ft., while in the amount of drilling that was done with the Keystone machine, there was no change made in the rope and the part that was used is still good for a number of feet yet. The superintendent and also Winston Bros. seem very well pleased and satisfied that the Keystone is far ahead of the Cyclone machine."

Yours truly, R. H. Horrell.

Parts of Mr. Kershner's letter, such as this, "the best day's work for each drill was 73 ft. in 10 hours for the rod machine and 71 ft. in 12 hours for the cable machine" cannot but be misleading. Referring to a letter from Mr. W. O. Winston, of Winston Bros., to Mr. Horrell, on the subject of this test, the fact is found to be that the Keystone cable drill averaged 51 ft. per day, whereas the Cyclone rod machine averaged but 46½ ft. per day. Furthermore, the 5-in. cable drill hole was made at a cost of 23 cents per foot, while the 3-in. hole cost 23¼ cents per foot.

We append Mr. Winston's letter, which may be regarded as an unbiased report of the "test."

"Your letter to Mr. Young at Hell Gate has been referred to us for reply.

"As you are aware, we were not personally on the ground, and therefore do not feel that we can accurately gauge the merits of the two machines, Keystone and Cyclone. Our records show that the holes drilled by the Cyclone cost 23¼ cents per foot, and those drilled by the Keystone cost 23 cents per foot. The Cyclone averaged 46½ ft. per day, and the Keystone 51 ft. per day. The holes drilled by the Keystone were 5 in. in diameter and those by the Cyclone 3 in. in diameter.

"We are very well satisfied with both machines, and can say that we consider the Keystone certainly as good a machine for contractor's use as the Cyclone. In some cases the Cyclone, being light, might have some advantage. In other cases, the Keystone will be the better machine to have."

Yours very truly, Keystone Driller Co.

New York, July 8.